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Distribution and diffusion of Norwegian ICT competencies

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Preface

This paper is financed by the FAKTA programme, run by the Norwegian Research Council. We would like to express gratitude to the steering committee in general, and programme coordinator Tor-Jørgen Thoresen in particular, for trust and patience during our work.

The conclusions and considerations expressed in this report are fully the authors', and not necessarily compatible with those of Norwegian Research Council.

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Abstract

Although much ICT-related innovation activities take place in non-ICT industries, it has hitherto been difficult to measure the extent of such activities in a quantitative and comparative way. Most ICT overviews have used traditional *producer*-focused classifications (like net employment in manufacturing of office machinery) and thereby ignoring the large and widespread activities in ICT *user* industries.

This paper uses a new empirical approach to determine the extent of ICT in the economy. The method used is identifying and quantifying employees with formal ICT competencies by respect to company sizes, regions and industries. This method, based on register data, provides us with a completely new approach to understanding the use and extent of ICT in also ICT *user* industries and not least in public sector, of course in addition to providing a more realistic picture of ICT activities in regular ICT industries as well.

The main results from this report are:

- It is commonplace to look at ICT producer industries when accounting for national or regional ICT performance. Our study demonstrates empirically how ICT knowledge is found in many industries. About 60 percent of Norwegian ICT competencies are found in what we term 'user industries'. Much ICT-related innovative capasity is located outside mere ICT producing industries.
- Dominant industries, measured in ICT skill density, are Power and water supply, Oil extraction and Machinery and equipment. The single largest ICT 'industry' is still Business services and computing, with about 6.000 employees with formal skills in ICT. The most ICT-intensive industries are still producer industries like Electronic and optical industries and Business services and computing. Lack of international studies with the same approach makes it, however, impossible to judge how these industries perform in an international comparison.
- Industries experiencing the fastest increase in ICT intensity, measured as higher-than-average ICT growth and lower-than-average overall employment growth, are Printing and publishing, Chemicals, Transport equipment, Machinery and equipment and Non-metal goods. Education comes out least well in such an overview. This activity shows both decreased number of ICT skilled and increased number of 'regular' employees, resulting in a profound decrease in ICT density.
- Although the number of ICT-skilled persons working in small, private companies has increased fast during the 90s, this must be related to a general increase in number of employees in small companies in this period. The density of ICT-skilled persons has, however, increased most in the largest companies during the 90s.
- Public sector has slightly increased the number of ICT-skilled employees the last decade. However, this increase has neither matched the overall increase in public sector employment nor the increase in number of ICT-skilled

persons. The result has been a profound relative decrease in ICT skills in public sector, particularly sharp in Education.

- The Number of ICT-skilled working in central areas is about three times higher than people working in less central areas. This is a stable pattern over time, meaning that the relative distribution between the two types of regions has not changed profoundly between 1989 and 1999.
- Private sector ICT-skills has grown faster than in public sector, regardless of centrality. Growth in central private sector has been almost four times as rapid as public sector in rural areas. The growth difference between public and private sector in central areas is slightly less than in rural areas.
- Over a ten year period, between 30 and 40 percent of the ICT-skilled persons stay in the same industry. There is higher turbulence in industries like Transport Equipment, Building and Construction, Business services and Public administration/defense, while Power and water supply, Education, Other services and Oil extraction are industries with quite high stability.
- In terms of mobility between central and rural areas, the dominant pattern is stability. About 90 percent have not moved from central to rural – or the other way around – between 1989 and 1999. In addition, we actually find a net positive mobility from central to rural areas, and not the opposite. The reason is partly the fact that there are so many persons working in central areas in the first place. The *share* moving from rural to central areas is much higher (18 percent) than the other way around (seven percent).
- Are there too few ICT-skilled persons in the economy? Given the lack of such skills in Public sector in general and Education in particular, the immediate answer is ‘yes’. For example, bringing Education up to an average national density level would require 2.000 more ICT-skilled persons alone. In addition to the obvious ICT skill deficit in Education, we also point towards possible deficits in large Trade and Business service companies.

Table of contents

Tables

Figures

Chapter 1. Why and how ICT matter

A central topic to policy-makers the last decades has been how to help private industry exploit the economic benefits of information and communication technology (ICT). ICT, broadly understood as all those artefacts and processes that involves or centres round the use of microprocessors, have changed profoundly the last decades. This change has evolved along two axes. Firstly, there has been a *diffusion process*, i.e. ICT has been used in an increasing number of instruments, processes, devices, gadgets, machinery and so on, in a wide range of industries. The second process has been *performance increase*, i.e. the speed of microprocessors, the performance of mobile telephones and computer screens has increased faster than the price.

These changes have lead to the widespread, but discussable, opinion that ICT producer industries represent important growth industries, vital to any national industrial-technological strategy[1]. Such line of thoughts has had wide influence on the shaping of industry policies in Norway. IT Fornebu – a newly established co-location area in the capital area for ICT companies – has for example been based on this line of thoughts.

This perspective, that new technology-based industries are profound growth industries, is not new. One of the first to relate to the concepts of growth and technological development is Joseph Schumpeter[2], arguing that new industries gradually replaces old industries, in a constant creative-destructive process. During the 70s and 80s, Schumpeter's theories were developed and refined by Christopher Freeman[3]. Freeman shows most attention towards macro-economic variations in how new technological systems develop and diffuse, and his analysis and perspectives on how ICT diffuse and are exploited in different countries have had a wide impact on policy shaping in Western economies during the last decades. Following in the footsteps of Nikolai Kondratiev and Schumpeter, Freeman has been very explicit in describing how large technological systems follow the same cyclical patterns, as seen in the last centuries of capitalism with coal power, waterpower, petroleum and finally information technology.

This perspective is not completely without empirical support. The prominent ICT-based example is Silicon Valley, a small area outside San Francisco with about 2.000 prosperous new-technology-based companies[4]. Also, the Cambridge phenomenon belongs to the same category; a story about how small companies based on new

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[1] See for example Aftenposten march 16. 1999 (http://www.aftenposten.no/nyheter/okonomi/d73640.htm) (interview with Christian Thommessen) or chronicle by Kristin Klemet in Dagens Næringsliv May 16. 2000.

[2] See for example Schumpeter, J. A. (1954), *Capitalism, Socialism and Democracy.* 3d ed., New York, Harper and Row

[3] See for example Freeman, C. (1988); *Structural crisis of adjustment: business cycles and investment behaviour*, in Dosi et al; Technical Change and Economic Theory, Pinter Publishers, London and New York

[4] Saxenian (1994)

technology emerged in the 80s around the university-environment in Cambridge[5]. Similarly, for stock markets, some new-technology-based companies have represented large and fast value increases, like NOKIA in Finland, Ericsson in Sweden or Opticom in Norway. In 1999, the third, fourth and sixth fastest growing company measured in change in stock market value (OSE main list) were IT companies; Tandberg, Nera and Avenir – all with a tripling or higher of stock market value this year. On the SME list, seven out of ten most increasing companies were IT companies; with Opticom's 2328,57 percent increase as highest change[6].

Still, there are good reasons to be critical to this way of approaching the economic impact of ICT. Many of these above-mentioned companies' incomes have yet to prove any relation to the expectations reflected by the stock prices. In fact, the so-called 'new economy' boom has gradually lost much of the glory it was once surrounded by. As seen from the case of Ericsson during spring 2001, no ICT companies grow automatically into the sky. Large job losses in Hitachi and Fujitsu in the summer of 2001 further underline that ICT-based companies follow ordinary rules of capitalism. Similarly, Internet companies, some of them claimed to stand above fundamental economic rules, have in fact only proven one rule, and that is that easy company entry is always associated with easy company exit.

But if production of ICT equipment is not at the core of economic development, what is? Freeman himself argues that in addition to successful producer industries there will be important (ICT) user industries to benefit from the new paradigm. Freeman has never actually one-sidedly defended ICT manufacturing as the only way to take advantage of emerging cycles involving new technology. Freeman argues in other words that there are two paths for ICT-oriented approaches to technology policies: A producer perspective, and a user perspective.

In this report we will focus on the latter. This approach represents an important contribution to our understanding of the role of ICT in other industries then the producing ones, simply because such comparative figures has not yet been made. A major reason why such overview have still not seen the light of day, is how economic statistics is gathered and arranged; by using 'industry product' instead of 'knowledge content' as the denominator. We will come back to this point more closely in the next chapter.

What we want to explore in this paper is in which Norwegian companies, industries and regions do we find important amounts of ICT activities? Related to this question is to find the balance between large and small companies, between ICT user and producer industries and between central and peripheral parts of the country, and how these balances change over time.

Chapter 2 is divided in three. First we present the regular way of mapping ICT activities. Secondly, we discuss why this approach is unsatisfactory, and thirdly – in relation to this – we present an alternative method for mapping ICT activities.

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[5] Segal (1985)

[6] *Opticom*, with literally no income, was in Dec. 1999 priced at 20,3 mrd kroner, or about five percent of total Norwegian state budget.

Chapter 2. Mapping ICT activities

2.1 The regular approach

It is commonplace to start any mapping of ICT activities with the traditional industry classification, NACE[7]. This classification categorises companies into groups of industries by using their major product as the denominator. The Norwegian definition of the ICT industry is presented in Table 14 in the Appendix. The table shows 22 industries, whereof eight are new from year 2000. The definitions are more or less according to international standards.

The ICT industry is in itself expanding. According to a survey performed by Kapital Data, the 500 largest data companies increased their turnover with about 20 percent between 1997 and 1998 (Aftenposten 30. juni 1999). Similarly, results from research performed by the employer organisation IT-næringens Forening, Jørn Sperstad, claims that the industry's export has doubled from 1993 to 1999; from six to twelve billion NOKs.

Looking at the ICT industry in an international perspective, OECD has over the last years collected comparative statistics from different member countries on the ICT industry. Figure 1 shows an overview of share of business employment in different countries in OECD member countries in 1997. Norway is here in the top group between five and six percent, together with Sweden, Denmark and Finland[8].

Figure 2 shows the ICT industry's R&D activities as share of total business R&D activities in various OECD countries in 1997. Norway is just below the OECD average with about 30 percent, compared to 35 percent for the whole OECD area.

Figure 3 brings an overview of ICT trade in OECD countries measured as share of total trade in the countries. Norway, with a high share of trade related to petroleum sales, is located at the far end of the scale with about five percent; half of the OECD and EU averages.

Figure 4 brings an overview of ICT as share of business value added for various OECD countries. Norway's level is quite close to the OECD and EU averages, about 5 percent compared to six and seven percent.

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[7] Nomenclature générale des Activités économiques dans les Communautés Européennes

[8] A problem with these OECD figures is that they do not contain any exact definition of which industries are included in this overview. What we know, is that the overview is based on a sum of activities in a range of given industries related to an ICT product. This demonstrates our point that it is a problematic issue to define ICT industries by products instead of knowledge or technological content in the production.

Figure 1: ICT employment as share of total business employment in OECD countries (source: ICT at a glance, OECD, 2000?)

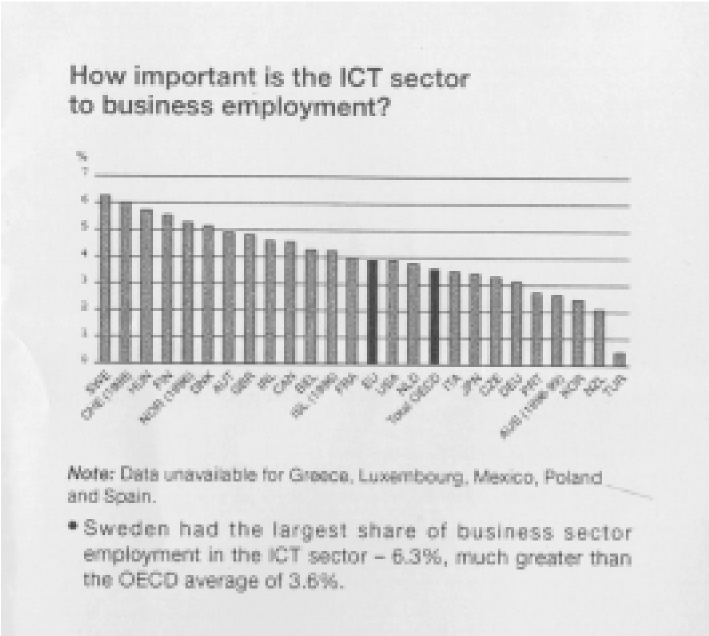


Figure 2: R&D expenditures as share of total business R&D in OECD countries, 1997 (source: ICT at a glance, OECD, 2000?)

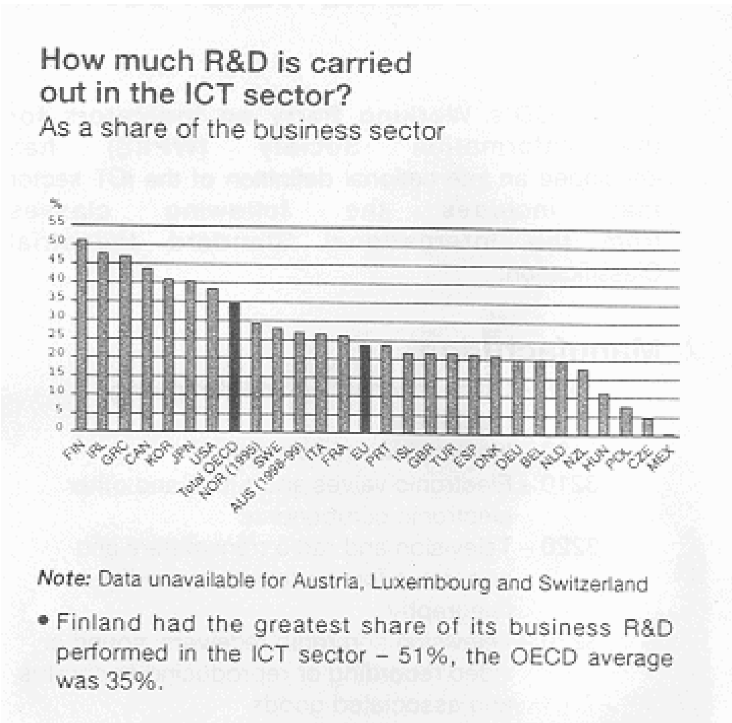


Figure 3: ICT trade as share of total business trade in OECD countries, 1997 (source: ICT at a glance, OECD, 2000?)

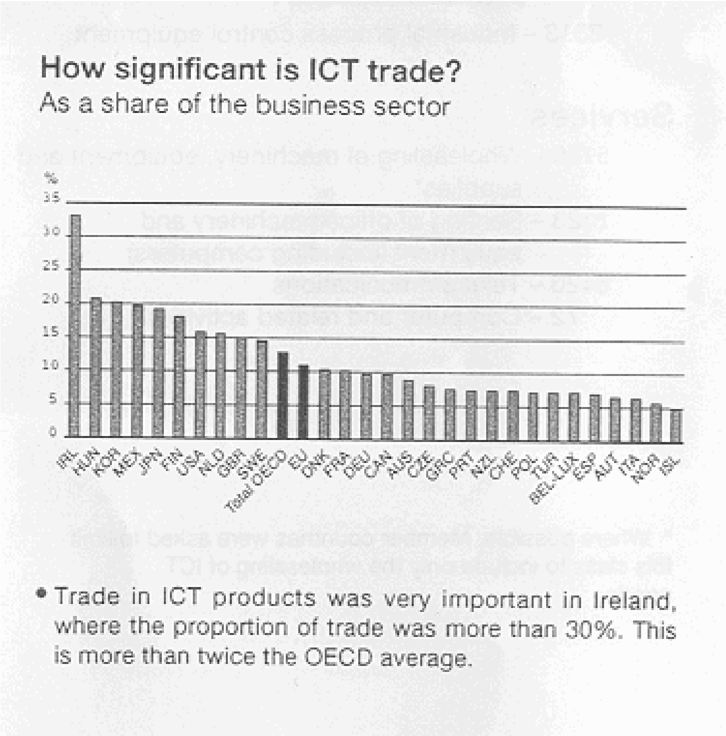
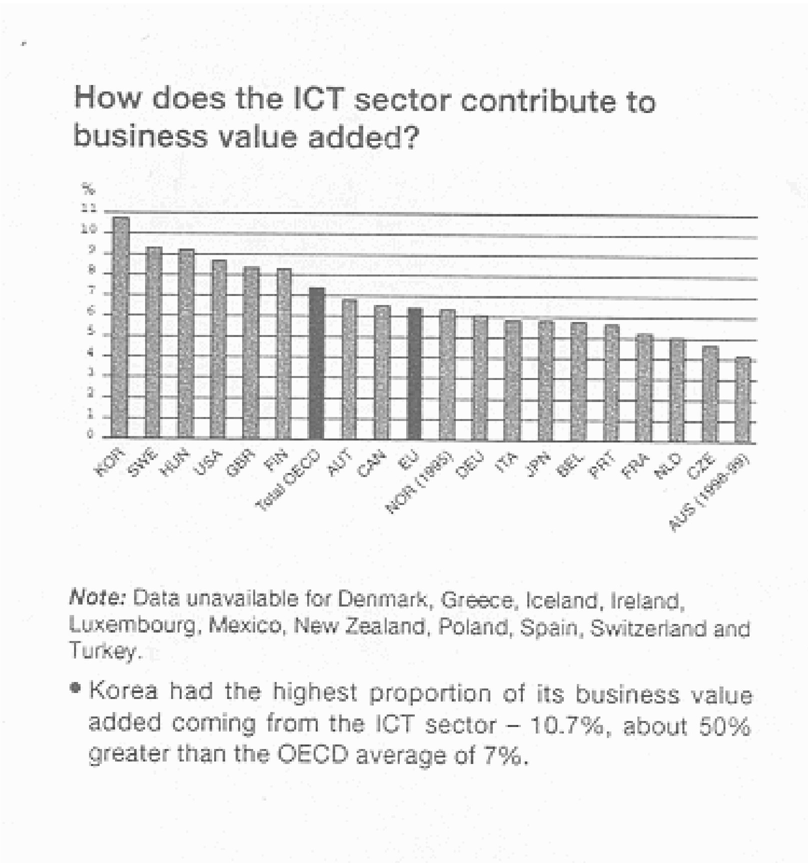


Figure 4: ICT share of business value added in various OECD countries, 1997 (source: ICT at a glance, OECD, 2000?)



These figures from the OECD folder *ICT at a glance* provides a fruitful, first comparative approach to the role of ICT sector in countries in the Western hemisphere. However, in addition to representing relevant information, we think that such presentations also contribute to increased confusion around important issues.

2.2 Why the regular approach is incomplete

Ordinary ICT overviews are based on a count of companies producing products belonging to specific product groups. This categorisation of industries suffers from two major drawbacks. Firstly, each company is given one code only (for instance *33,200 Man. of measuring and controlling equipment*), representing the company's product. This has again two unwanted side effects. Firstly, for companies with multiple products, the one with highest importance is chosen as denominator. Here we run the risk of including parts of a company with no ICT activities being performed (like IBMs legal division), or vice versa: Important ICT activities taking place in a smaller part of a non-ICT classified company are not counted (like the network division of Kværner Offshore).

The second undesirable effect is that counting industry *employment* always includes *all* activities performed within the firm. This is a marginal effect in companies where all but core activities are externalised, but when both administration, genitors, transporting and cleaning personnel work in an ICT classified company, these people are also counted as ICT employment. In other words, the NACE definition does not hit the (moving) target well in terms of determining the extent of ICT employment or activities.

Secondly, and in extension to what we have already said, is the fact that the NACE ICT classification does not contain any ICT user industries. Some user companies – industries like transport, retailing, automobiles etc. – have proven to perform a high degree of ICT activities. Using the NACE definition, which is a producer approach to ICT, leaves industries with many skilled ICT employees out of the head count.

Using ICT producers as a gateway to the new economy has other drawbacks as well. The major criticism is that the role of ICT-related manufacturing still seems minor to the overall impact of ICT, both in employment, value added and growth.

We will draw attention to three empirical facts.

I) As seen in the OECD figures, average ICT shares of value added in Europe is about five to six percent. We regard this as quite low, compared to the attention the industry has got from policy-makers both in Norway and elsewhere.

II) Looking at employment growth figures for the OECD area 1970-1993 (Figure 5), we find that manufacturing of computers and manufacturing of electronic equipment were two of the few manufacturing industries in this period with positive employment development (although Japan and not Europe represented most of this growth). However, we see from the figure that growth is more complex than just taking place in so-called knowledge-intensive industries (in the narrow sense of the word). The most profound growth sectors are various kinds of business services and social services, together with hotels and restaurants. The fastest growing industry in OECD in this period was in Rubber and plastics.

III) Further, looking at ICT industries' value added in OECD countries over time (Figure 6), we actually find that contributed share of total GDP in various countries by ICT companies is stable and in some countries diminishing, like in the Netherlands. An important message is therefore that the *ICT industries* is not necessarily the right place to look for economically important ICT activities.

This points towards the following two conclusions:

I) The role of ICT-based (or, more broadly, so-called knowledge-based) activities as growth industries is ambiguous. There are for example other, non-high-tech areas that grow faster, both measured in employment or as share of GDP.

II) It is really hard to measure the real, sound extent of the ICT economy with any of the traditional measures. The extent of ICT activity is basically a question of how we define ICT industry. For example, defining ICT activity as those companies producing ICT products, we ignore the vast ICT activities in user industries. Those industries exploring opportunities of the new technology without being ICT industries are totally left out in such overviews.

Figure 5: Sectoral employment growth in the OECD area 1970-1993. Source: OECD, Technology, productivity and employment. OECD 1996.

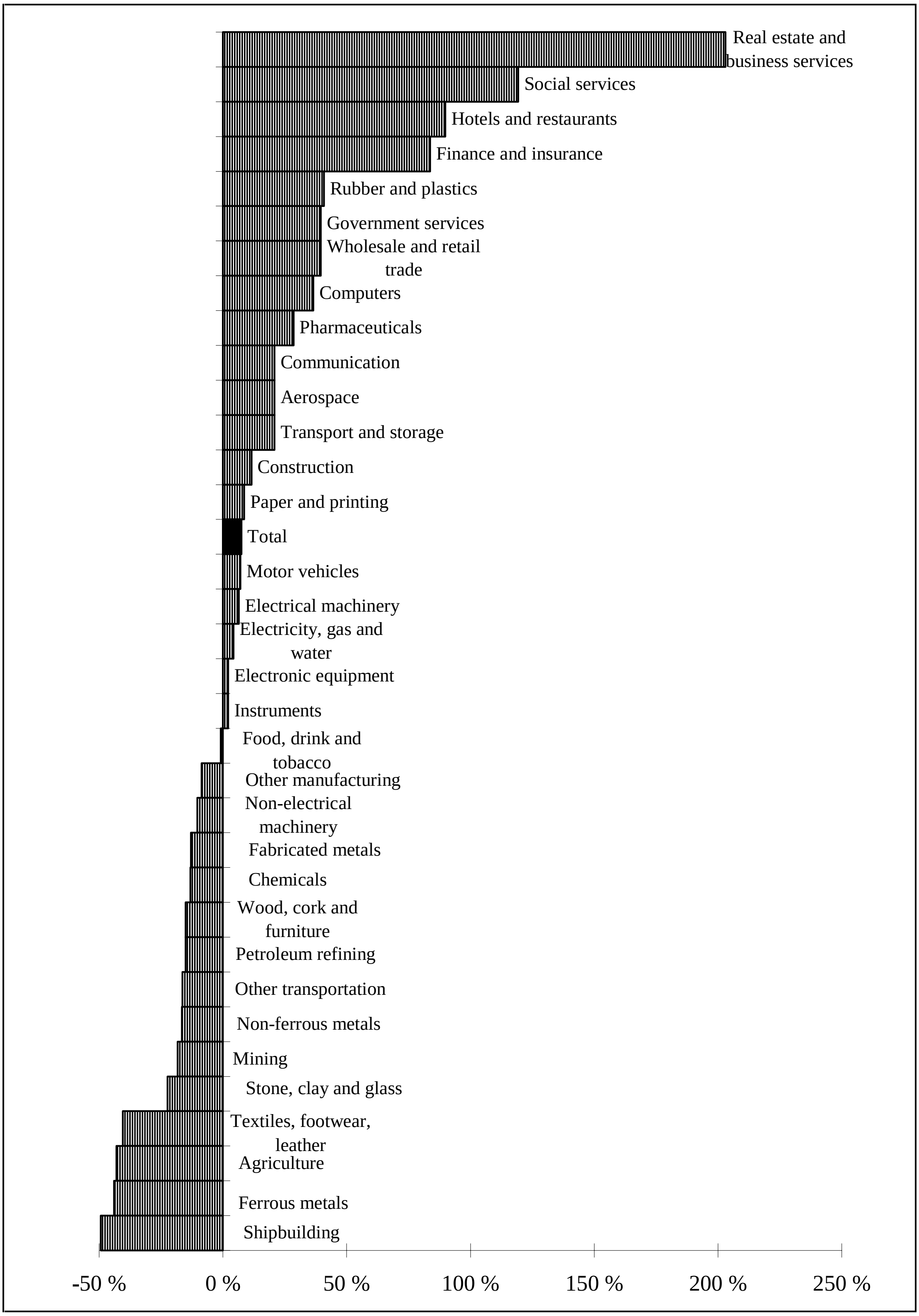
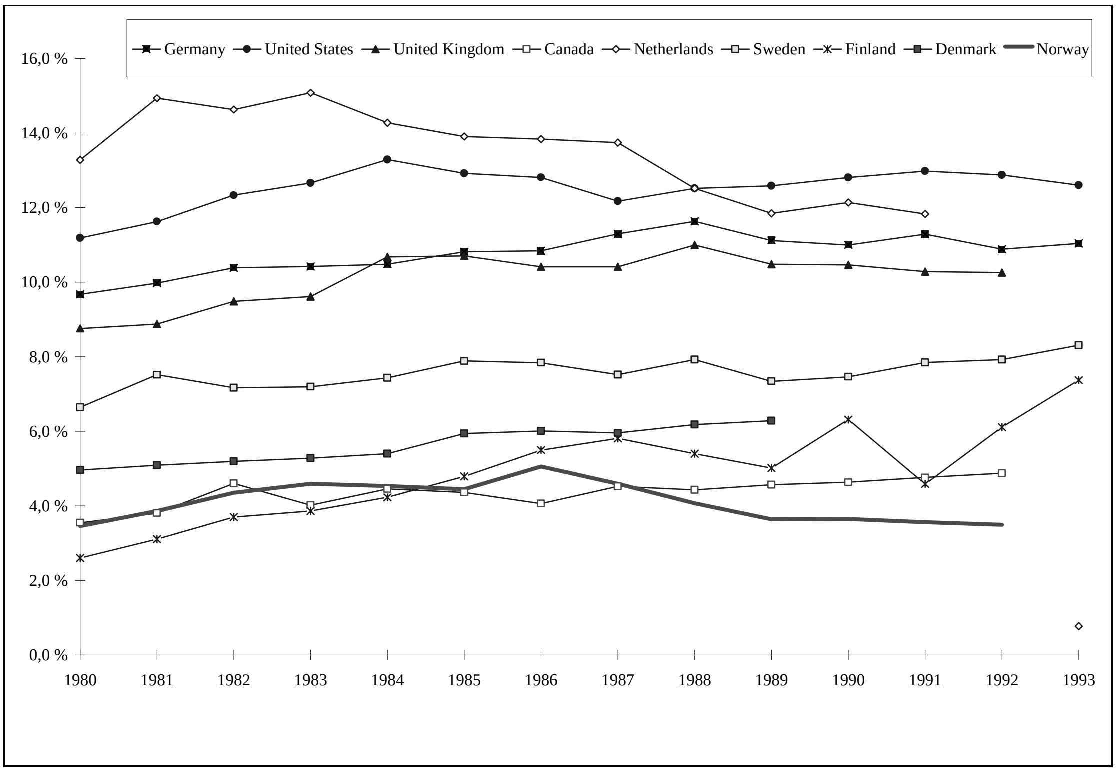


Figure 6: Value added in ICT manufacturing industries 1980-1993, various OECD countries (ISIC 3825, 3832 and 385). Source: OECD, STAN



2.3 The competencies approach - how to include both users and producers

The examples above have shown that almost all attempts to measure the economic effects from ICT have been focusing on the growth and expansion within the ICT industry (however defined) and not the effects in user industries. As information and communication technologies are generic technologies, they can be implemented and used in many industries and sectors. Graphical industries, geology, clinical medicine, food processing, statistics and advanced modelling as well as science and research are other user areas that have excessively implemented ICT tools the last decade.

To grasp all ICT knowledge, within both producing and using companies, we use person-level data on *ICT education* from national registry data. By manually deciding what educational directions and or levels we regard as being ICT-related, we are able to pick those employees in Norway with formal ICT competence, and decide their location in industries, regions and sectors. In the register files, every employee working in Norway is tagged with his or her highest education exam. This would be the basis of our approach to map ICT competencies in the Norwegian economy. The method is on the one hand better than the traditional NACE classification of ICT industry, because we will also get reports of people with ICT education working in user industries, and thereby finding the most ICT intensive ICT user industries in Norway. We get to see the ICT intensity in public sector, variations by geography, by company sizes and by company location.

But which educations should be regarded as representing ICT-competence? There are actually a lot of different skills used in the production of computer hardware and software[9]. Even though there is a core of basic algorithms, general principles of programming logic – actually being an expert on SQL does not make you an expert of HTML, or TCP/IP etc. In addition there is the more hardware related fields like fibre optics, wireless communication etc. In this particular project we were rather generous – if in doubt –in most cases we have included rather than excluded an education.

There are about 6.000 education codes, but most of them are on levels below higher education. We decided to go for employees with higher ICT education (college and university) We sorted out those educations that looked like ICT-related; i.e. containing 'computing', 'electronics', 'programming', 'cybernetics', 'DAK/DAP', 'informatics', ', 'telecommunication' etc. We ended up with a list of 129 education codes (see Appendix for list). This is the canonical list we use from now on.

Notice four drawbacks with this way of mapping ICT competencies.

i) Register data is a combination of data from many public data sets (employment information, company registers, social security information etc.). This means that there of course are, as in all large data sets, mistakes, missing values, wrong codes for companies, industry, location, employees etc. The set is, however, in general of quite good quality. The data are collected and maintained by Statistics Norway.

ii) We only have access to *the* highest exam per individual. This means that a person with an ICT exam as a part of a higher degree in social science will not be covered by our statistics. A person with the same ICT exam *without* the social science degree will be covered. This is regrettable, but the only way to do it as long as every person in the register is denoted with only one passed exam.

iii) We equal ICT competencies with formal education in ICT. There are of course many persons that have no exams in ICT, but with extensive, informal skills in the topic. We have reasons to believe that this group of people is not insignificant, given the fact that ICT skills have been in demand for quite some years now. Regrettably, we have no possibility to map real competencies, although we fully accept their existence.

iv) Persons are counted as one with no regards to how high degree or exam they have in ICT related topics. A person with one year from college is counted for as one, the same is a person with PhD from a university.

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[9] One could argue that the division between software and hardware is a bit artificial or misleading. The CPU is primarily a piece of software, it is just not stored on a magnetic disk but burned into a chip, the same goes for network adapters, graphic adapters etc.

Chapter 3. The empirical results

3.1 Background figures

The study period is the ten-year interval 1989 to 1999[10]. In this period several patterns occurred with respect to ICT skills in the Norwegian economy.

Firstly, the number of ICT skilled persons increased with 50 percent, from about 16.500 to 24.500 persons. This is shown in Figure 7, distributed on private and public sector. The rise has mainly taken place in private sector. Average total annual net increase is about 900 persons, or five percent. The annual net increase was higher the last three years, with about 1.200 new persons with ICT skills entering full-time[11] labor market (Table 1).

[10] Due to a break in the company data series in 1993/94 (the transition from use of Employer Number and Employer Sub Number to use of Organisation number), tracking persons on company level in order to map stability or personnel turnover is quite difficult. Also, the transition from ISIC to NACE classification in 1995/1996 is making hard to present overviews on industry-level for a longer time-span. However, by using detailed transition tables and other adaptation mechanisms[10], we have managed to create what we believe is reliable time-series. About 2/3 of the companies with four digit ISIC (pre 1995) were given a 5-digit NACE code by using transition tables. Most of the remaining companies were given NACE codes according to their NACE codes in 1995/1996. The remaining handful companies were given 2-digit NACE codes based on general product group as given by the ISIC classification.

[11] Part-time is defined as working persons with income less than a certain amount, as defined in footnote 13. (må forandres hvis flere fotnoter)

Figure 7: Number of full-time employed ICT-skilled persons in the Norwegian economy 1989-99, by sector[12]

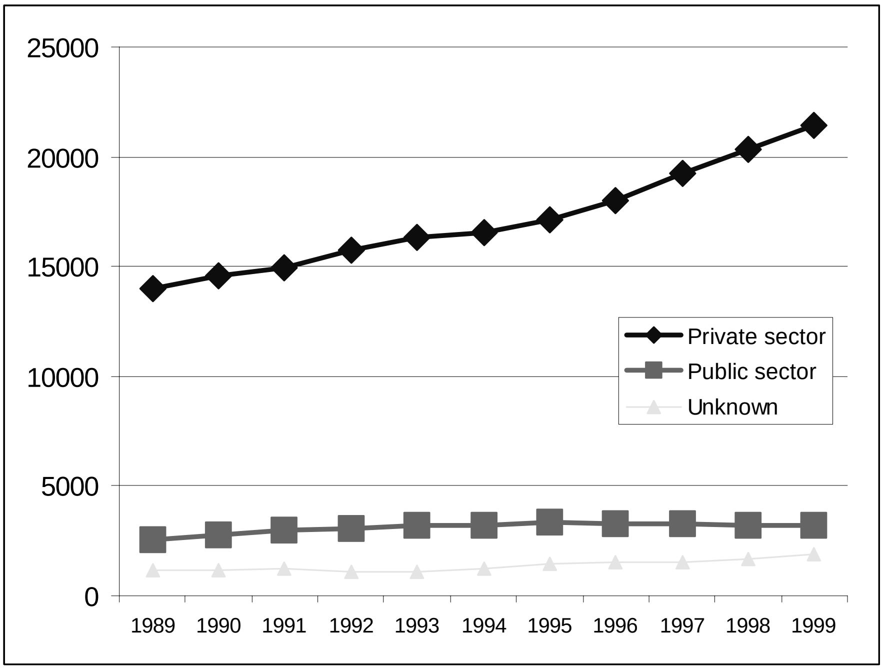

Table 1: Increase in ICT skilled persons in labour market, from 1989-91 to 1998-99

	1989-90	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*
Annual increase	785	691	700	710	390	939	901	1209	1205	1323

Secondly, the share of people with ICT skills working full-time has increased faster than the average employment development the last ten years. Total number of full-time employees regardless of education has increased exponentially from 1.2 million in 1989 to about 1.45 million in 1999. At the same time, the share of persons with ICT skills increased from 1,3 to 1,6 percent.

Table 2: Share of ICT skilled persons in Norwegian labour market 1989 to 1999

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Share of employees	1,38 %	1,45 %	1,47 %	1,51 %	1,55 %	1,55 %	1,59 %	1,64 %	1,65 %	1,68 %	1,69 %

[12] All employment figures in this report are from the annual Norwegian employer register database (1989 to 1999), gathered and maintained by Statistics Norway, used under licence by STEP Group.

3.2 ICT competencies in different company size classes[13]

3.2.1 Background

The debate about company structure, economic performance and growth is a classical one. On the one hand we find the 'locomotive' school of thought, arguing that it is the largest companies that play the dominant role in innovation, research and market competencies, and that smaller companies are mere subordinate copiers and followers to the larger companies. Empirical evidence supporting this approach includes large companies' R&D spending, innovation performance and share of domestic value creation and market dominance. It follows from this view that the policy implications is to help large companies to grow and expand internationally, and for example to stimulate research in the largest companies and learning and copying abilities in smaller ones.

On the other hand, there are those that claim that small companies are more technologically flexible due to their size; that small companies are better to take advantage of new technology faster than large ones, and that entrepreneurship is better rewarded within small companies. Defenders of this school point to the fact that sales from new products are normally high within innovators and the increased importance of small companies for employment, of course in addition to the growing number of emerging, small ICT-based companies. The followers of this school argue that a good growth policy is to stimulate innovation in – and market access to – small companies, to ensure economic flexibility and supply of niche technologies.

This debate has been particularly emphasised in Norway, as the economy consists of a few, internationally important large companies, like Kværner, Norsk Hydro, Norske Skog and Orkla on the one hand, and a wide range of smaller companies on the other. As Norway is one of the smallest Western countries (measured by habitants), the country size is also reflected in the industry structure, with quite many small and medium-sized companies, and relatively few really large companies. Companies with 1-9 employees represent three quarters of all companies[14], and the largest ones represent less than half a percent of all companies. The figures are provided in the table below.

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[13] The register data are not clear on what should constitute 'employment'. The main border cases are of course people in part time jobs. In addition there are more or less clear register errors, like persons with income but seemingly no job (no workplace code), or no income but registered with a job code. To overcome these problems we have defined employment as all those people with both i) earning more than a given minimum yearly wage and ii) registered with a job code. The minimum wage is set to 100.000 NOK in 1989, and increased by three percent each year. The limits are therefore 100.000 NOK (1989), 103.000 (1990), 106.100 (1991), 109.300 (1992) etc. and 134.400 in 1999 (last year of our study). Setting a base limit on wages make the definition of employment quite narrower than Statistics Norway uses. Officially, employment is basically any period of paid employment, including counting any person working part time as 'one'. A job code is the number any company is given when the established. From 1989 to 1995, the required job code is equal to an 'employer number' (arbeidgivernummer). From 1996, we use 'organisation number' (organisasjonsnummer).

[14] 'Company' does here also include public institutions, like schools, health care etc.

Table 3: Company size structure in Norway, 1999.

Size class	Share of companies	Share of employees
1-9	75,2 %	17,2 %
10-49	19,6 %	32,1 %
50-99	2,5 %	14,5 %
100-249	1,1 %	14,7 %
250+	0,4 %	21,5 %

It is on this background we want to explore the distribution of ICT skills in different company size classes, and how this evolves over time. We do not expect the distribution to be ‘normal’, as large companies structurally have more need for ICT competencies than smaller ones; you don’t need to install an internal network to run a kiosk. We would also expect an increased share of ICT skilled persons over time working in larger companies, as a result of the demand of such skills in the last part of the 90s and not at least as a result of increased wages for such competencies.

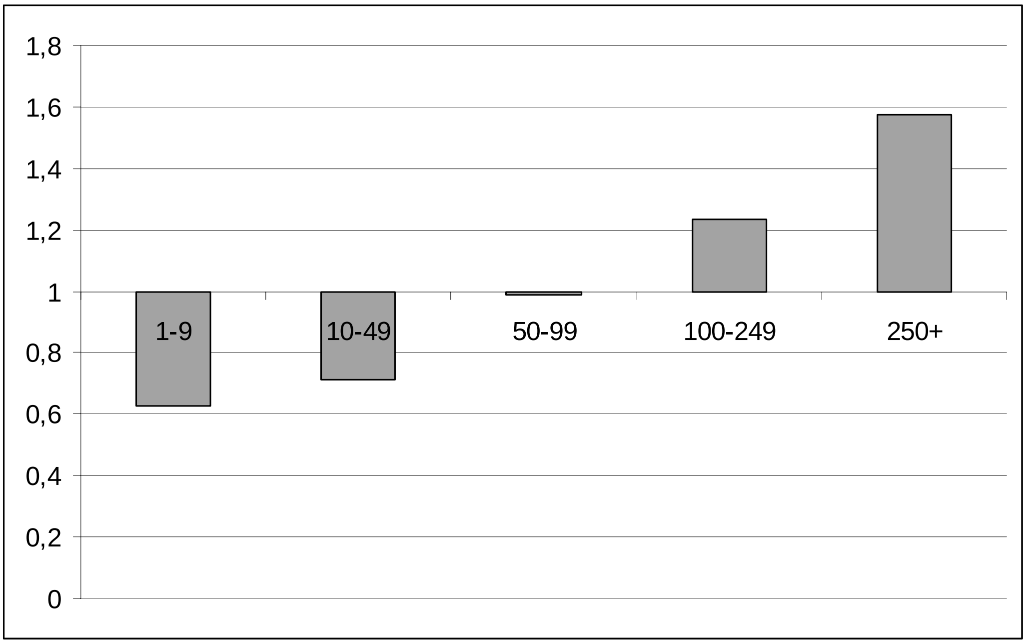
3.2.2 Results

We find support for our first hypothesis; number of ICT employees grows with increased size class. The probability of an ICT-skilled person working in a very large company is three to four times higher than working in a small company. In comparison, the chances for *any* employee to work in a very small or a very large company is around 20 percent in both cases (Table 3)[15], [16].

[15] In 1999, the group of largest companies employed about 21 percent of all employees, but 34 percent of all ICT skilled persons this year. This gives a ratio on about 1,6, whereas 1 is the ‘normal’ for all size classes. For the smallest companies, the ratio is about 0,6. But, as we stated above, there is not necessarily ‘wrong’ in this; the figure below is just as much an indication of different needs within different size classes.

[16] At this point, we face the question of whether small companies are dominantly new companies, if they dominantly represent outsourced activities from large companies or if they are subsidaries of large companies. The existing data do unfortunately not allow us to look closer at these interesting issues.

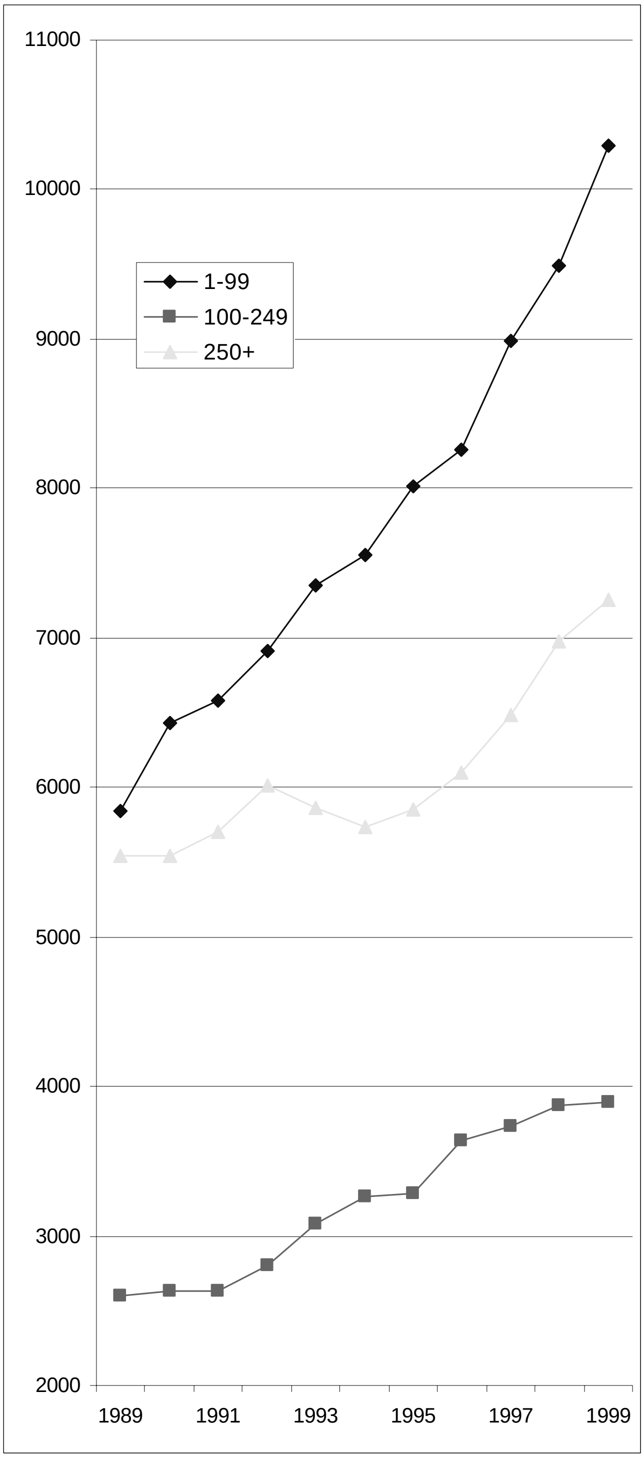
Figure 8: ICT probability index and company size class: Share of ICT skilled employees / share of total employment for each size class. 1999. Private sector. N = 978.957 (all) and 21.448 (ICT-skilled)



A better indication of ICT skill distribution is how the share varies over time. Are there over time more or less people working in the smallest size classes? One could argue that large companies *by nature* have easier access to capital, and therefore more easy access to ICT competencies than smaller companies. We would therefore initially expect that larger companies attract an increasing number of ICT skilled over time, to the disadvantage of small companies.

We find that small companies actually employ a larger share of ICT-skilled persons over time. In 1989, about 6.000 ICT skilled worked in companies with less than 100 employees; in 1999 it was more than 10.000. At the same time, the largest companies increased from 5.500 to 7.000 (Figure 9).

Figure 9: Number of ICT-skilled working in different size classes, private industries, 1989-1999



Looking at this more in detail, the fastest increase has actually taken place in some of the smallest size classes; companies with 10-99 employees. The slowest growth has been in the largest companies and in micro companies.

Table 4: Change in number of ICT-skilled persons by size class, 1989 to 1999

Size class	**1989**	**1999**	**Increase (percentages)**
1-9	1490	2320	156 %
10-49	2812	4903	174 %
50-99	1543	3074	199 %
100-249	2603	3896	150 %
250+	5543	7255	131 %
All	**13991**	**21448**	**153 %**

A related way to look at the distribution of ICT competencies across different size classes is to look at the share of total number of ICT-skilled employees in each size group, and compare 1989 and 1999. This is done in the table below.

The table shows that although the distribution is uneven, the share does not change to the disadvantage of small companies over time. In 1989 about 30 percent of all ICT- skilled persons worked in companies with 1-49 employees. In 1999, the share had increased to 34 percent. At the same time, the share working in the largest class sizes fell from 59 to 52 percent.

Table 5: Share of total number of ICT-skilled employees in each size class group, 1989 and 1999.

	1989	**1999**
1-9	11 %	11 %
10-49	20 %	23 %
50-99	11 %	14 %
100-249	19 %	18 %
250+	40 %	34 %
All	100 %	100 %

Does this mean that small companies have won the ICT-skill battle? As we shall see, it is a question of how we measure the phenomenon. One reason why the figures above look like they do is that total employment has increased faster in the smallest size classes than the larger ones during the last decade: While the number of persons working in the largest groups has been quite stable the last ten years, the number of employees in small companies has increased by 30 percent or so. This means that even though the total number of ICT-skilled persons has increased in the smallest size classes, the question of *density* is another matter.

The table below shows ICT-skilled persons as share of total employment in each size class. There are large variations across company size classes with regard to how density has evolved. While the average increase is almost three persons per 1.000 employees, both micro and small companies (1-9 and 10-49 employees) have increased slower than this average. The largest company groups have increased faster than average, fastest of all are companies with 50-99 employees, with almost twice the density increase compared to average.

Table 6: ICT density in different size classes, 1989 and 1999 (ICT skilled employees per 1.000 employees, in different size classes).

Increase	1989	1999	Increase
1-9	8,42	9,28	0,86
10-49	8,27	10,50	2,23
50-99	9,44	14,60	5,17
100-249	13,96	18,25	4,29
250+	18,51	23,22	4,71
All companies	**12,00**	**14,76**	**2,76**

3.2.3 Summing up

We have found that although the number of ICT-skilled in small companies has increased fast, this is related to a general increase in number of employees in small companies during the 90s. When we correct for general growth, we find that the density of ICT-skilled persons has increased most in the largest companies during the 90s.

However, there are theoretically based reasons to question whether this gives reason to worry, as i) small companies may structurally have less need for ICT skills than larger ones, and ii) it is a running debate whether economic development is dominantly created by large locomotives or by small, flexible companies. Perhaps a more viable approach to the localisation of ICT skills is found not in size classes, but in different industries. This topic is treated in the next section.

3.3 ICT competencies in different industries

3.3.1 Background

One central argument in this paper has been the long-lasting, widespread lack among social scientists and policy-makers in incorporating ICT user industries in ICT indicators. We have argued that ICT competencies are commonplace in both user industries and producer industries, and that both sectors are vital to get a full picture of ICT-related innovation activities.

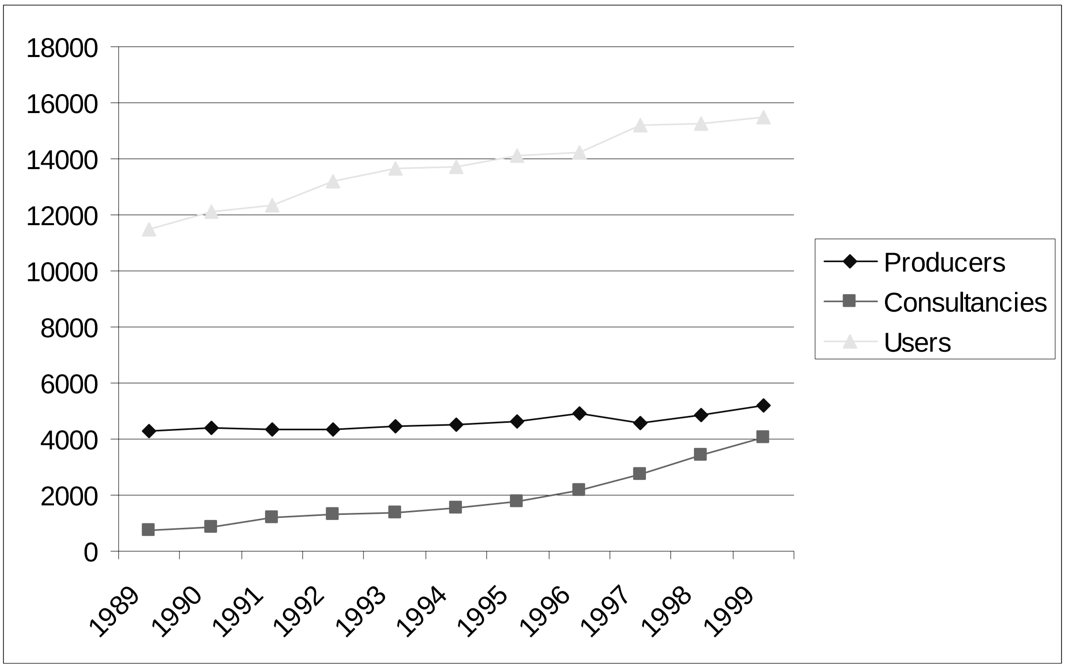
In this section, we will turn our attention to the distribution of ICT competencies in different industries. As we shall see, the traditional producer industries are the most ICT intensive industries, measured in persons with formal background in ICT related topics. But also traditional user industries, like Oil extraction, Machinery and Power and water supply are quite extensive users of ICT. The results are shown in the table below.

3.3.2 Results

It is commonplace to refer to empirical evidence from ICT-based consulting services when describing profound ICT growth the last decade. This is not wrong; our figures show that ICT-based consulting services have increased their number of ICT-skilled persons by more than 2.000; every fourth new ICT-skilled person entering the labor market has entered consulting services.

What is not so often talked about is that the net increase in *user* industries has actually been higher, and that it started earlier than in consulting services. While the ICT growth in consulting services really took off in 1994-1995, the increase in user industries started a couple of years before; 1991-1992.

Figure 10: Number of ICT-skilled working in respectively ICT producer industries[17], ICT consultancies[18] and user industries, 1989-1999.

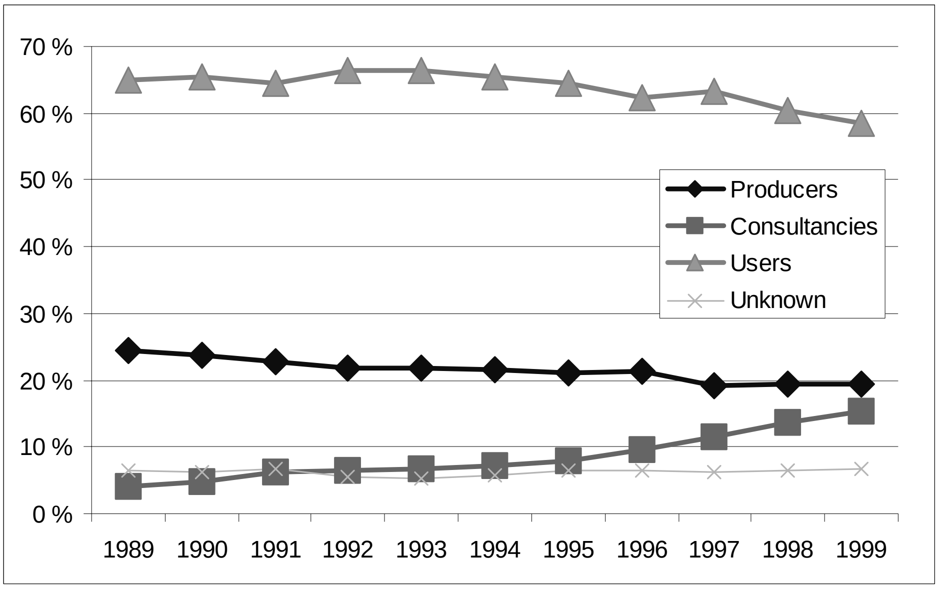


Looking at ICT shares, we find that in 1989, more than ¼ of all persons with ICT skills worked in ICT producer industries, while less than five percent worked in ICT consultancy services. In 1999, the share had converged to approximately 20 percent for each. Most ICT-skilled people still work in what we have termed 'user industries', i.e. all industries not covered in producing or consulting industries. In 1989, the share was 70 percent; in 1999 the share had shrunk to 60 percent (Figure 11).

[17] ICT producers is defined as those companies belonging to NACE 30 (Man. of Office machinery), 31 (Man. of Electrical appliances), 32 (Man. of Radio and television), 33 (Man. of Medical instruments), 642 (Telecom), 723 (Computing), 724 (Databases maintenance), 725 (Maintenance and repair of office machinery) and 726 (Other computing).

[18] Defined as NACE 721 (Machinery consultancies) and 722 (System and software consultancies)

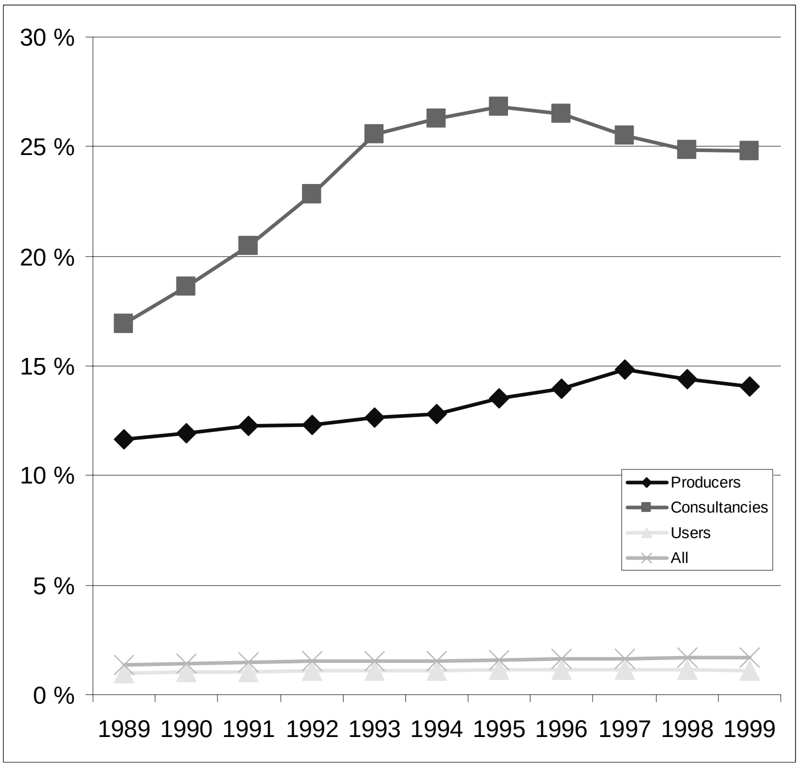
Figure 11: Share of ICT-skilled working in respectively ICT producer industries, ICT consultancies and user industries, 1989-1999.



The reason why user industries have so many ICT-skilled persons has to do with size. If we control for total employment, we find that ICT density in consultancies of course is much higher than in user industries, but also that ICT density actually increased very rapidly during early 1990s, and stabilised from 1994 and forward on, at about 25 percent. In other words, about one of four persons working in ICT consultancies has ICT as his – yes, it is most often a he – highest degree from college or university.

At the same time, density in user industries has been quite stable at about one percent. Density in ICT producer industries has increased slowly, from about 12 to about 14 percent in this period (Figure 12)

Figure 12: ICT density in ICT producer industries, consultancies and user industries, 1989 to 1999.



Looking at this more in detail, we find that the industry that attracts the most ICT-skilled persons is, not surprisingly, Business services and Computing[19]. In 1999, more than 8.000, or about one third of all ICT-skilled employees worked in Business services. This is more than a doubling since 1989. Other large industries with ICT activity (Trade, Transport and communication (incl. Telecom) and Electronic and Optical industries) have only experienced marginal changes in the number of ICT-skilled persons this past decade.

The top 15 ICT employer industries are provided in Table 7.

[19] We use a 27-industry separation. This categorisation is unfortunately not directly comparable to the division between ICT producers, consultancies and user due to overlapping categories. See Appendix for details.

Table 7: Number of ICT-skilled persons by employer industry, 1999

Top 15 employer industry	ICT skilled persons	Percent of total
Business services, computing	8168	33 %
Trade	2687	11 %
Transport and communication	2446	10 %
Electronic and optical	2386	10 %
Public administration, defence	1450	6 %
Education, teaching	1371	6 %
Other services	742	3 %
Power and water supply	736	3 %
Building and construction	730	3 %
Oil extraction	720	3 %
Financial services	618	2 %
Machinery and equipment	605	2 %
Transport equipment	599	2 %
Health care and social services	413	2 %
Chemicals	277	1 %

Although we now know something about in which industries we find most ICT skilled persons, we do not yet know anything about density. To get a fuller picture of ICT distribution, we will have to correct for industry size. The number of ICT skilled as share of total employment by industry is presented in the table below (per 1.000).

Table 8: Industrial ICT density: ICT skilled per 1.000 employees in different industries 1999.

Top 15 industry	ICT density
Electronic and optical	123,28
Business services, computing	59,49
Power and water supply	45,31
Oil extraction	29,34
Machinery and equipment	28,72
Transport and communication	19,32
Chemicals	17,81
Transport equipment	17,46
Norwegian average	**17,00**
Other services	16,08
Financial services	14,91
Pulp and paper	12,01
Trade	11,69
Public administration, defence	11,66
Education, teaching	10,90
Metals	8,63
…	

As we see, the list is topped by what we may call ICT *producer* industries; Electronic and optical industries and Business services and computing. In these industries, the density of ICT skilled persons is 40 to 50 per 1.000 employees.

The most ICT-intensive *user* industries are capital and information-intensive industries like Power and water supply and Oil extraction, in addition to Machinery and Equipment. Also, Transport equipment and Chemicals are above the national average, the same is Transport and Communication, because – as stated above – this group includes Telecom.

How have these patterns changed over time? If we look at the last decade, we find that the fastest growing industry in terms of number of persons is Business services and computing, with almost 4.700 more ICT-persons in 1999 than ten years before. This industry has in other words absorbed 50 percent of all newcomers with higher ICT education.

Table 9: Growth in ICT-skilled employees, by industry, 1989-1999, total increase = 8853 persons.

Industry	Growth	Share of growth
Business services, computing	4673	53 %
Transport and communication	643	7 %
Public administration, defence	499	6 %
Trade	412	5 %
Transport equipment	280	3 %
Electronic and optical	255	3 %
Health care and social services	248	3 %
Other services	237	3 %
Machinery and equipment	227	3 %
Financial services	214	2 %
Chemicals	155	2 %
Building and construction	154	2 %
Oil extraction	122	1 %
Printing and publishing	111	1 %
Food and beverages	54	1 %

We will also look at changes in density between 1989 and 1999; that is which industries have increased their share of ICT-skilled persons of total employment most? The table below provide such an overview. It gives figures for changed share, share 1999, share 1989, number of ICT skilled in 1999 and increase in number of persons from 1989-1999, by industry.

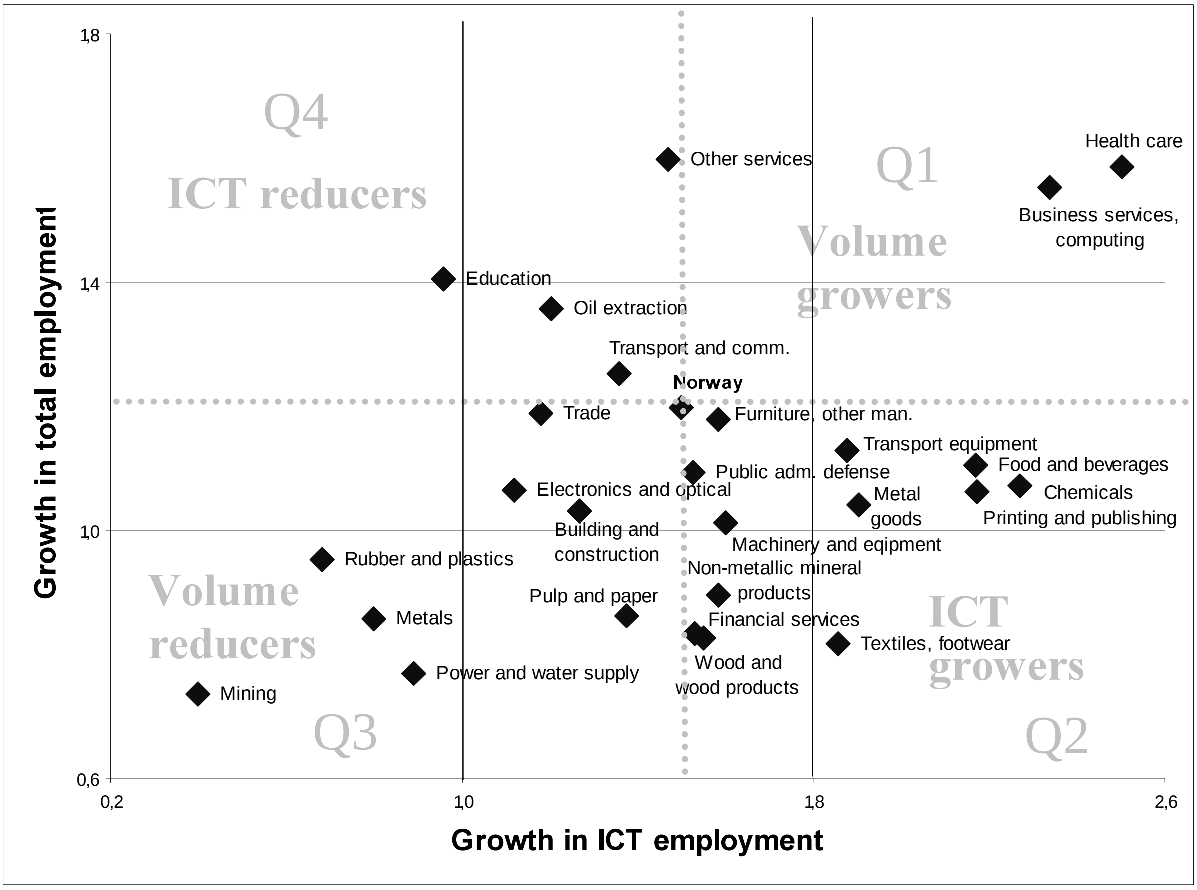
The most rapid growing industry is Business services and computing, with an increase in density of about 20 persons per thousand employees. The density has increased with two thirds, from 40 per thousand in 1989 to 60 per thousand in 1999. Another industry that has increased the ICT density quite profoundly, is Machinery and equipment, from 20 to 30 per thousand employees.

Table 10: Change in ICT density, 1989 – 1999, share of ICT skilled in 1999 and 1989, number of ICT-skilled in 1999 and increase in number of ICT-skilled persons, by industry.

Industry	Density change (ppts) 1989-1999	Density 1999	Density 1989	Number of ICT-skilled 1999	Increase (#) 1989-1999
Business services, computing	19,98	59,49	39,51	8168	4673
Machinery and equipment	10,54	28,72	18,17	605	227
Chemicals	9,41	17,81	8,41	277	155
Transport equipment	6,96	17,46	10,49	599	280
Financial services	6,79	14,91	8,12	618	214
Power and water supply	6,20	45,31	39,11	736	-91
Electronic and optical	6,13	123,28	117,15	2386	255
Pulp and paper	4,47	12,01	7,54	103	28
Printing and publishing	4,15	8,47	4,32	206	111
Public administration, defence	3,30	11,66	8,36	1450	499
Norway	**3,16**	**17,00**	**13,84**	**24758**	**8853**
Metals goods	2,61	5,77	3,15	99	47

By using the data above, it is now possible to look closer at variations in overall employment change on the one hand, and ICT change on the other. The following figure demonstrates how these two growth indicators vary across different industries. The figure is divided in four, where the Norwegian average (dotted line) across the two axes separates the quadrants.

Figure 13: Change in ICT skilled persons vs growth in total employment 1989-1999, by industry.



Q1 represents industries with higher ICT growth and higher employment growth than average. We have termed these industries 'volume growers'. In Norway, only two industries experience this phenomenon; Health care and Business services.

Q2 cover those industries with higher ICT growth than average, but with lower overall employment growth, labelled 'ICT growers'. These are the most interesting industries in our perspective, as they have gone towards more ICT specialisation over time; increasing their stock of ICT skilled persons faster than average, while non-ICT employment has increased slower than average, or decreased. This category covers industries like Printing and publishing, Food and beverages, Chemicals, Transport equipment, Machinery and equipment and Metal goods.

Q3 covers those industries that come out less than average on both variables, like Mining, Rubber and plastics, Metals, Financial services, Public administration, Electrical and optical products and Wood and wood products. These industries are labelled 'volume reducers'.

Finally, Q4 represent those industries that have increased employment faster than average, but where number of ICT skilled persons has increased slower than average, or decreased. This covers Education, Oil extraction and Other services (personal services, guarding etc.).

3.3.3 Where do we find competencies gaps in private sector?

Is it possible to find some way to judge whether the distribution is uneven across industries or size classes? One could, for example, as a starting point argue that large companies *by nature* have easier access to capital, and therefore more easy access to ICT competencies than smaller companies, and that an ICT competence policy towards small companies therefore is relevant, regardless of industry. We have shown that ICT density has increased in larger companies the last ten years, to the disadvantage of small companies, which could clearly be used as a rationale for intervention.

Still, an empirical mapping of ICT skill deficiencies and surpluses should carefully take into consideration that large companies may in general have a much higher need of ICT skills than smaller companies do. Also, different industries may have different need for ICT skills. The following method for estimating ICT skill deficits has built in these assumptions.

We remember from earlier that average density in private sector was 25,3 ICT-skilled per thousand employee, but lower in small companies (18,2). Density in medium and large companies were 31,7 and 45,3. This gives us what we call a structural component; a weight indicating how much density in each size class varies from average density. Here, average density is calculated from private companies only.

Table 11: Structural component: Density[20] in size class divided by density in all classes

Size class	**Small (1-99)**	**Medium (100-249)**	**Large (250+)**	**All**
ICT density all industries	18,2	31,7	45,3	25,3
Structural component	**0,7**	**1,3**	**1,8**	**1,0**

How does this component apply to each specific industry? For an industry like for example Business services, we find that ICT density in small companies is 48,0, while average for this industry is 59,7. The small companies in this industry have in other words have a density that is (48,0 / 59,7 =) 0,8 times the average density for this industry. As we see from Table 11, this is slightly *higher* than what we should expect for small companies in average.

On the basis of these figures, one could therefore argue that small Business services have an ICT skill surplus. Large companies in this industry, on the other hand, have an ICT density that is 1,6 times higher average density in this industry. This is slightly less than what we would expect for large companies; 1,8.

The following figures provide an estimate of such relations in all industries and all size classes. The figures show density in industry size class divided by density in industry, minus structural component for actual size class. A negative number indicate deficiency, while a positive number indicate surplus. Only private industries with 100 or more ICT-skilled persons are included.

[20] Density refers to ICT skilled employee per 1.000 employee

Figure 14: ICT skills surplus and deficit in small companies, by industry (1999)

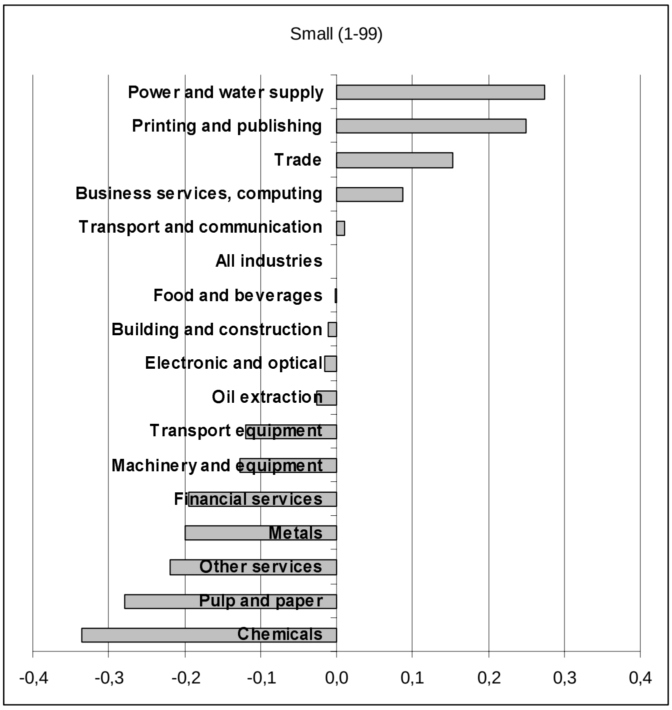


Figure 15: ICT skills surplus and deficit in medium-sized companies, by industry (1999)

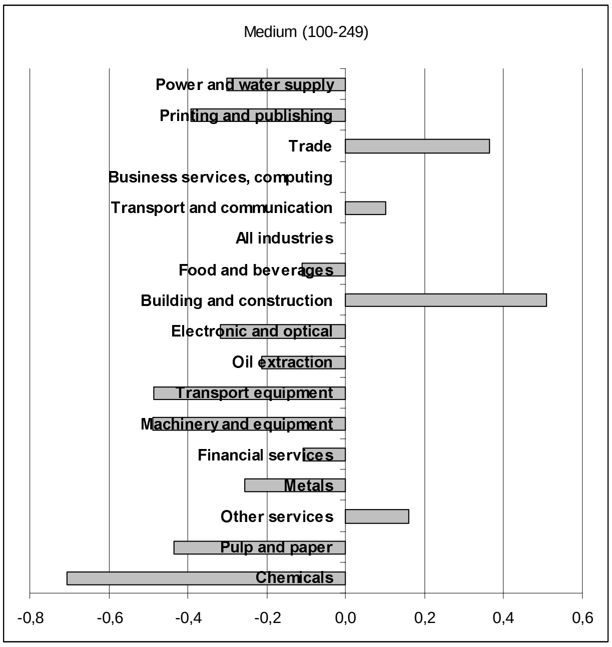
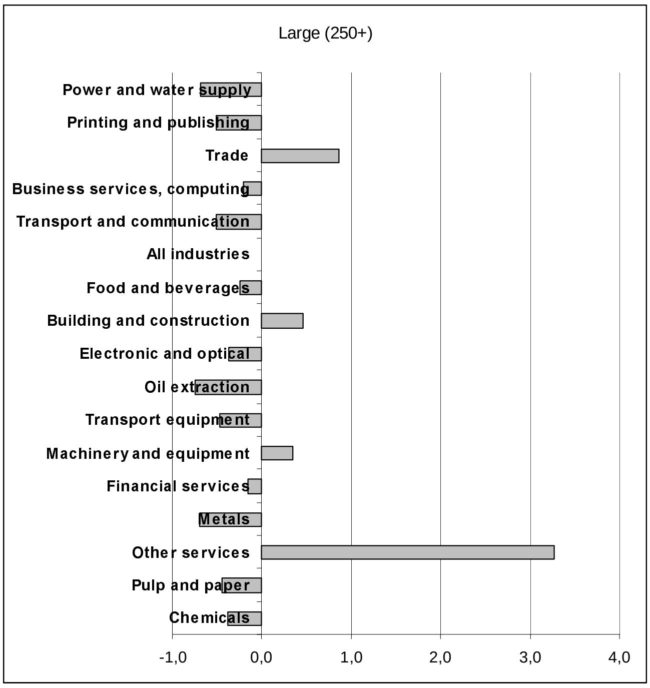


Figure 16: ICT skills surplus and deficit in large companies, by industry (1999)



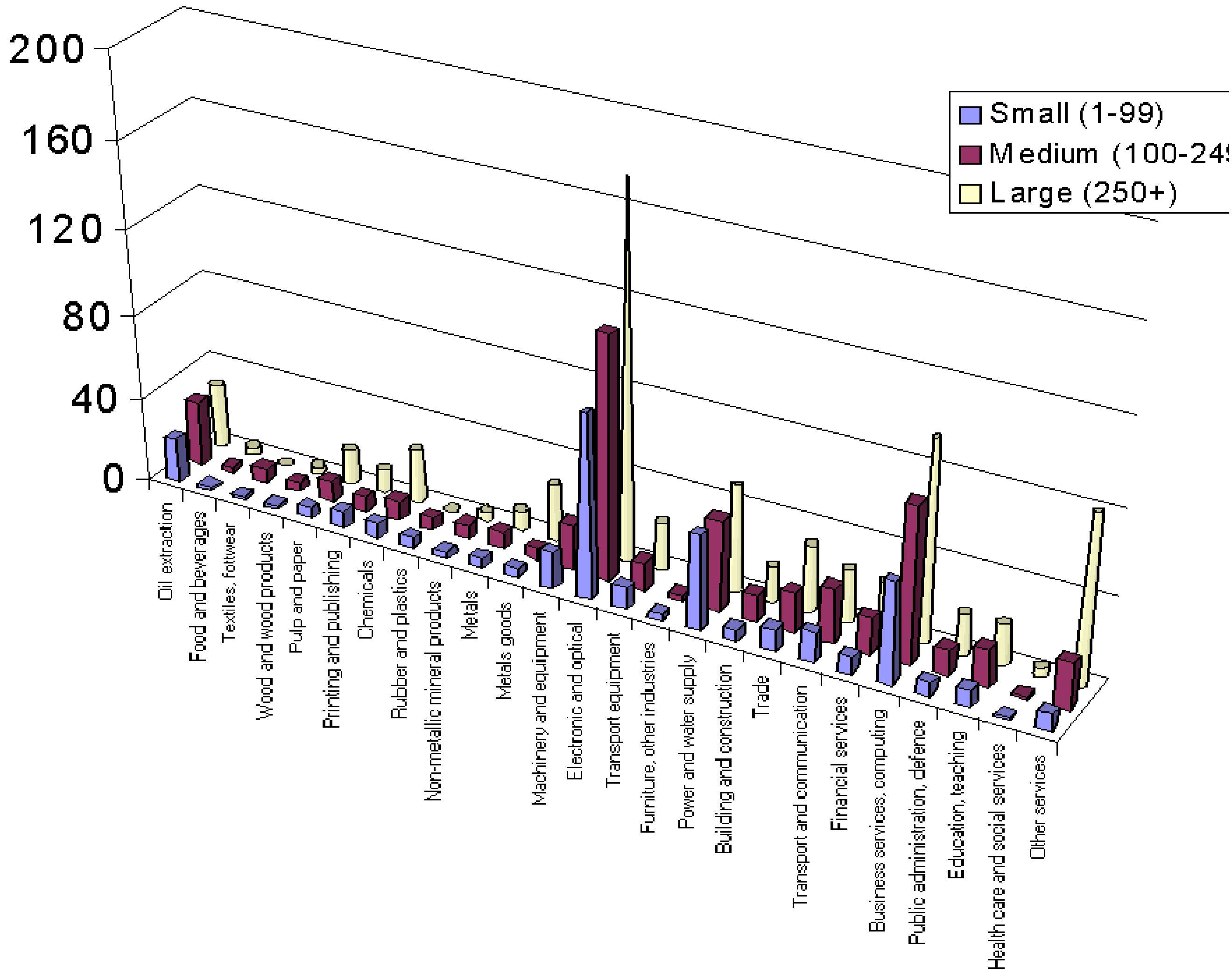
For some industries we find patterns of uneven distribution between size classes. Power and water supply and Printing and publishing are both industries that have ICT skill surplus in small companies, to the disadvantage of large ones. Small Trade and Business services companies also have excess ICT competencies, but not so much to the disadvantage for other size classes. In Other services, large companies have ICT skill surplus to the disadvantage of small companies in the same industry. Building and construction has a much higher density in medium-sized companies than expected[21].

3.3.4 Density by industry and size class

As seen above, ICT densities vary both across industry (see for example Figure 12, Table 6 and Table 10) and size class. How does density vary if we take into consideration *both* industry and size class? The following figure shows that there are large variations between different industries in how much the density differ within various size classes.

[21] The figure also provide that peculiar result that some industries have either surplus or deficiencies in all size classes; like Trade (surplus in all classes) and Chemicals, Pulp and paper and Financial services (deficit in all classes). The reason is that our figures do not take into consideration the weight of each size class. In Trade, with many small companies, average is close to average in small companies. In Chemicals, Pulp and paper and Financial services, we see that few and large companies lay average near average in large companies.

Figure 17: ICT density in different industries and size classes (ICT skilled per 1.000 employees), 1999



In Metal goods and Machinery and equipment the density in large companies is between four and six times higher than in small companies. In Power and water supply the density is quite the same regardless of size. The same goes for Printing and Publishing.

On average, ICT density is twice as high in large companies as in small ones.

3.3.5 Summing up

About 60 percent of Norwegian ICT competencies are found in user industries. Dominant industries, measured by ICT skill density, are Power and water supply, Oil extraction and Machinery and equipment. The single largest ICT ‘industry’ is still Business services and computing, with about 6.000 employees with formal skills in ICT. The most ICT-*intensive* industry is producer industries like Electronic and optical industries and Business services and computing. While Business services have increased both number of employees and number of ICT skilled faster than average the last ten years, the opposite process has taken place in Oil extraction.

The industries that have experienced the fastest increase in ICT intensity, measured as higher-than-average ICT growth and lower-than-average overall employment growth, are Printing and publishing, Chemicals, Transport equipment, Machinery and equipment and Non-metal goods.

A major concern is that Education comes out least well in such an overview. The industry has experienced both decreased number of ICT skilled and increased number of 'regular' employees, resulting in a profound decrease in ICT density. We will look closer at ICT skills and public sector in the following section.

3.4 ICT competencies and public sector

3.4.1 Background

During the last half of the 90s, a rapid wage increase among ICT- skilled personnel increased the threshold of hiring ICT-skilled persons. This wage increase was said to particularly harm public sector, as wages are more fixed and bonuses almost non-existing, as opposed to in the private sector.

This section will try to say something qualified about these developments. How much has public sector suffered from these developments? Has there actually been any traceable effect?

3.4.2 Results

We have already, as an illustration, seen that Education was the industry in Norway that experienced highest increase in overall employment and at the same time slower-than average increase in ICT-skilled persons, leading to the highest reduction in ICT density of all industries during the 90s (Figure 13). Average industrial 'density' in Norway today is about seventeen per thousand. In education, the same share is 35 percent lower.

It must me born in mind that ICT employment in public sector[22] has actually increased the last decade, from about 2.300 in 1989 to almost 3.000 persons in 1999 (Table 12).

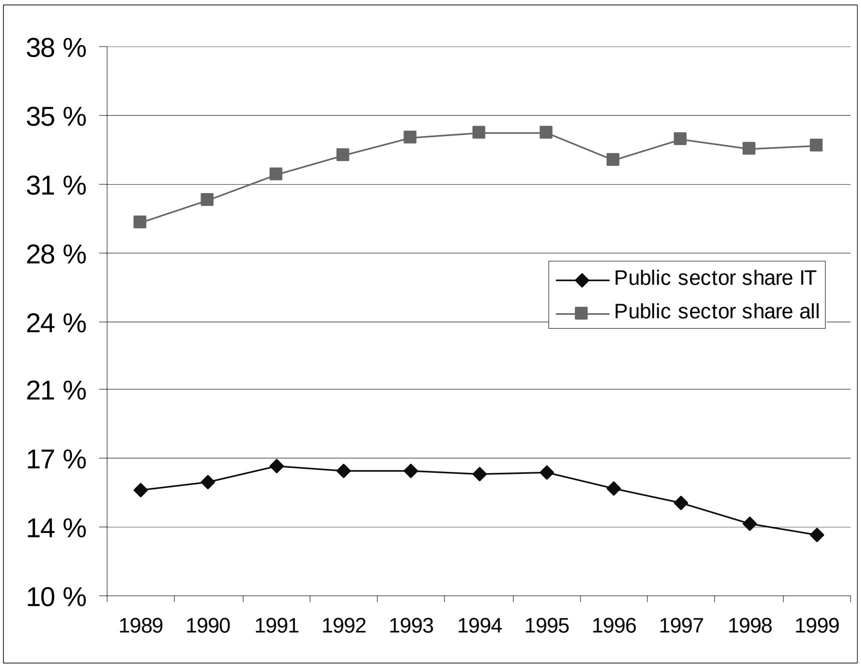
Table 12: Number of ICT-skilled persons working in public sector, 1989-1999

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Public sector	2550	2738	2977	3077	3197	3201	3332	3303	3310	3217	3234

[22] Here we define public sector as those activities whose prime products are teaching (any level), public administration, defence and healthcare. The advantage with this definition is that it covers our purposes quite well, and in addition follows the traditional industry classification, enabling us to quite easy use employment statistics. The disadvantage is that we include employment from minor private activities, like private hospitals (still very few in Norway) and private schools (like the Rudolf Steiner schools, some colleges, like BI and NHH). We also ignore a large bulk of people working in state-owned companies, like NSB (national railroad), NRK (public broadcasting company), Telenor (Norway's largest telecom company) and the oil company Statoil, to mention the largest.

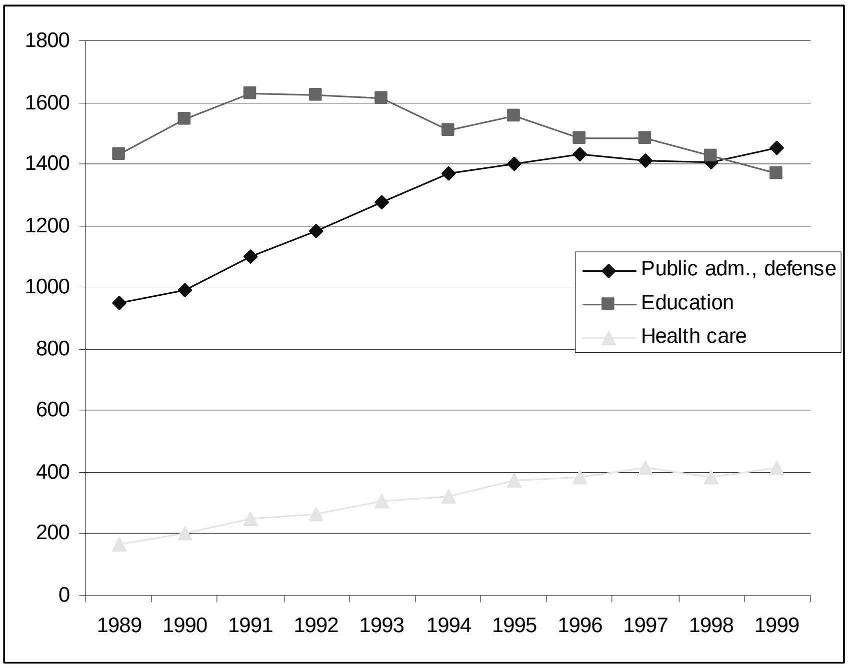
However, the 700 persons net increase represents less than 10 percent of total increase in this period. At the same time, public sector represent about one third of total employment in Norway. This points toward a quite undisputable fact from this mapping: Public sector started low and got worse off during the 90s. From 1989 to 1999, the share of all ICT-skilled employees working in public sector fell from 16 to 14 percent, illustrated in the figure below.

Figure 18: Share of employees working in public sector; all employees and employees with formal ICT-skills, 1989-1999



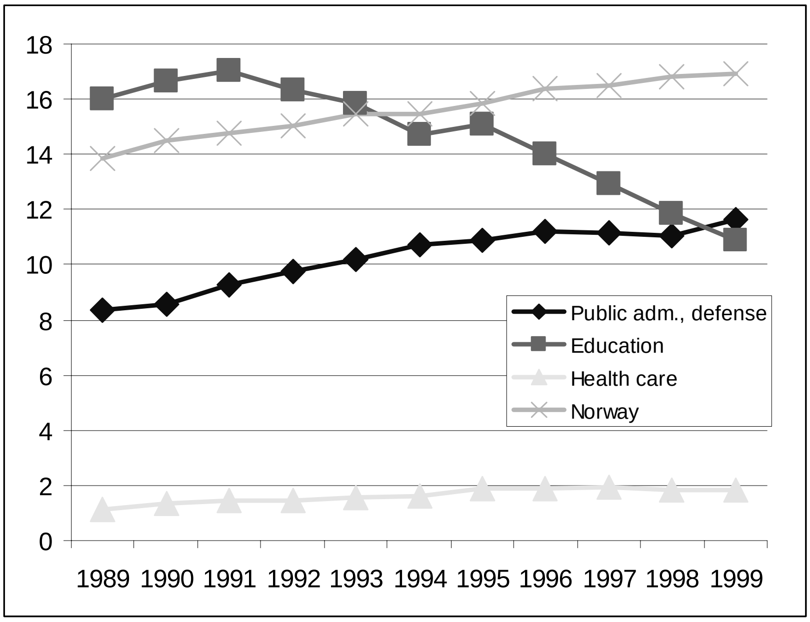
However, public sector is not a homogenous activity, but covers activities dominated by three fields; Health, Education and Administration/defence. How has access to ICT competencies varied across these activities? The results show that while Public administration and defence, and to a certain degree Health care, have increased the number of ICT-skilled, Education has actually had a net loss of people from 1991 and forward. In 1999, the number of ICT skilled is actually lower than in 1989, although there have been more than 8.000 new candidates entering the labour market in this period (Figure 19).

Figure 19: Number of employees with formal ICT-skills, public sector



However, these figures do not say anything of general employment development in these activities. What then about the change in density over time? This is shown in Figure 20. For Health services, the density is stable and low, on less than two per thousand. Public administration / defence has experienced increased density during the 90s, but has been lower than the national average all the time. Education has decreased their ICT density since 1991, from 17 per thousand to 11 per thousand. (National average has at the same time increased from 14 to 17 per thousand).

Figure 20: ICT density in public sector (ICT-skilled per 1.000 employee), 1989-1999



3.4.3 Summing up

Although public sector has slightly increased the number of ICT-skilled employees the last decade, the increase has neither matched the overall increase in public sector employment nor the increase in number of ICT-skilled persons. The result has been a profound relative decrease in ICT skills in public sector. The decrease is mostly found within Education.

3.5 ICT competencies in different regions

3.5.1 Background

In the crossroads between ICT and economic development, one argument has been that ICT may actually benefit more rural regions, dominantly because these technologies are place-independent: ICT equipment is accessible about everywhere, one may access Internet from everywhere, one may work from everywhere and one may learn from everywhere. This is for example one of the main conclusions in the influential Reinert and Schootbrugge report to the Ministry of Regional Affairs in 1999.[23]

It is correct that ICT equipment is quite widespread in Norway. There are two reasons for this. Norway is one of the wealthiest countries in the world, and at the same time the OECD country with highest wage equality[24]. For this reason, most people and companies have had the possibility to invest in digital equipment. Moreover, it is also often argued that Norwegian industry structure throughout the 60s and 70s was never dominantly influenced by standardized mass production, like manufacturing of cars and household electrical appliances like other European countries. Therefore, the transition to ICT-based service or goods production came much more easy than in countries anchored to ‘old’ production structures. As a result of these two factors (access to capital and low technology transition costs), the country is often in the front row on lists on ICT use, microprocessor per habitant, mobile telephony, number of pc’s per employee etc.

However, can we take for granted that these are processes that will take place equally in all regions? Clearly, one does not have to have a higher degree in ICT to take advantage of new technology. In many cases, informal learning and access to technology are vital ingredients in such innovative processes. Remote working does not demand a university degree in an ICT related topic.

Still, if one argues that ICT skills ar important for the future ability to innovate with ICT, the regional distribution of such formal skills is not unimportant. The following mapping will look at the geographical distribution of ICT-competencies in Norway, and how such patterns change over time.

[23] Reinert and Schootbrugge (1999).

[24] Moene and Wallerstein (2000)

3.5.2 Results

The regional distribution of ICT-skills is quite uneven. About 45 percent of all ICT-skilled persons work in the capital region covered by Oslo or Akershus counties; 11.400 of 24.500. It is also the capital region, and in particular Oslo, that has gained most of the new ICT-skilled persons the last decade: Half of the 8.000 new persons in this period found work in the capital region; 2.800 of them in Oslo.

The fastest growing region, relative to earlier position, was Aust-Agder. In 1989, the county employed about 11 percent of all ICT-skilled, in 1999 the share had increased to more than 12 percent. On the opposite end of the scale, we find Sør-Trøndelag, with a share reduction of about 1,2 percent points, from eight to seven. These results are shown in the Figures below.

Figure 21: Number of ICT-skilled by county, 1989 and 1999, ranked by number of ICT-skilled in 1999

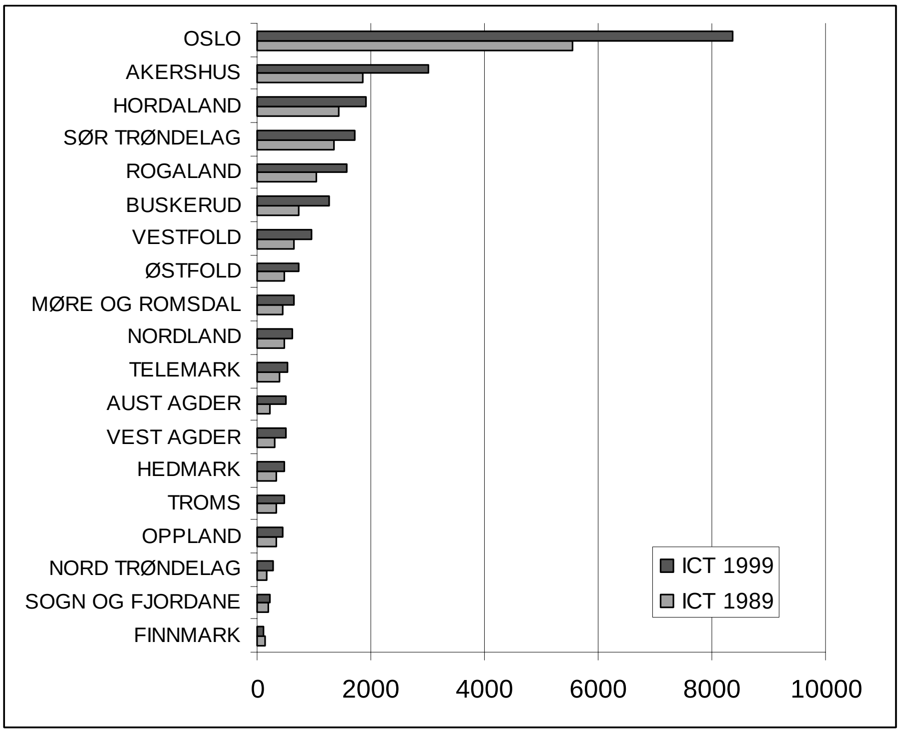


Figure 22: Share of ICT-skilled by county, 1989 and 1999, ranked by number of ICT-skilled in 1999

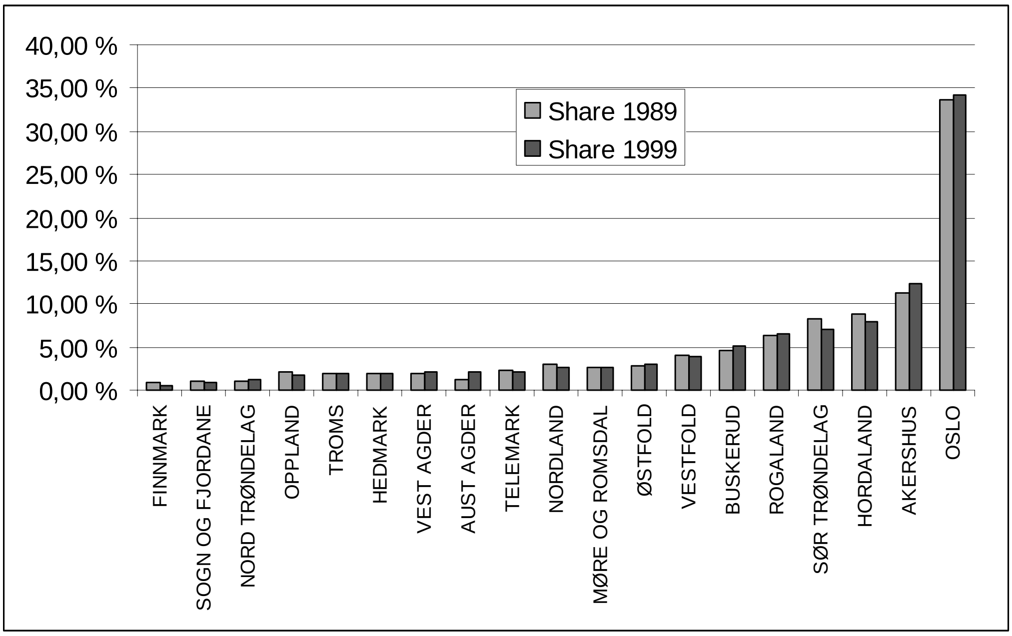
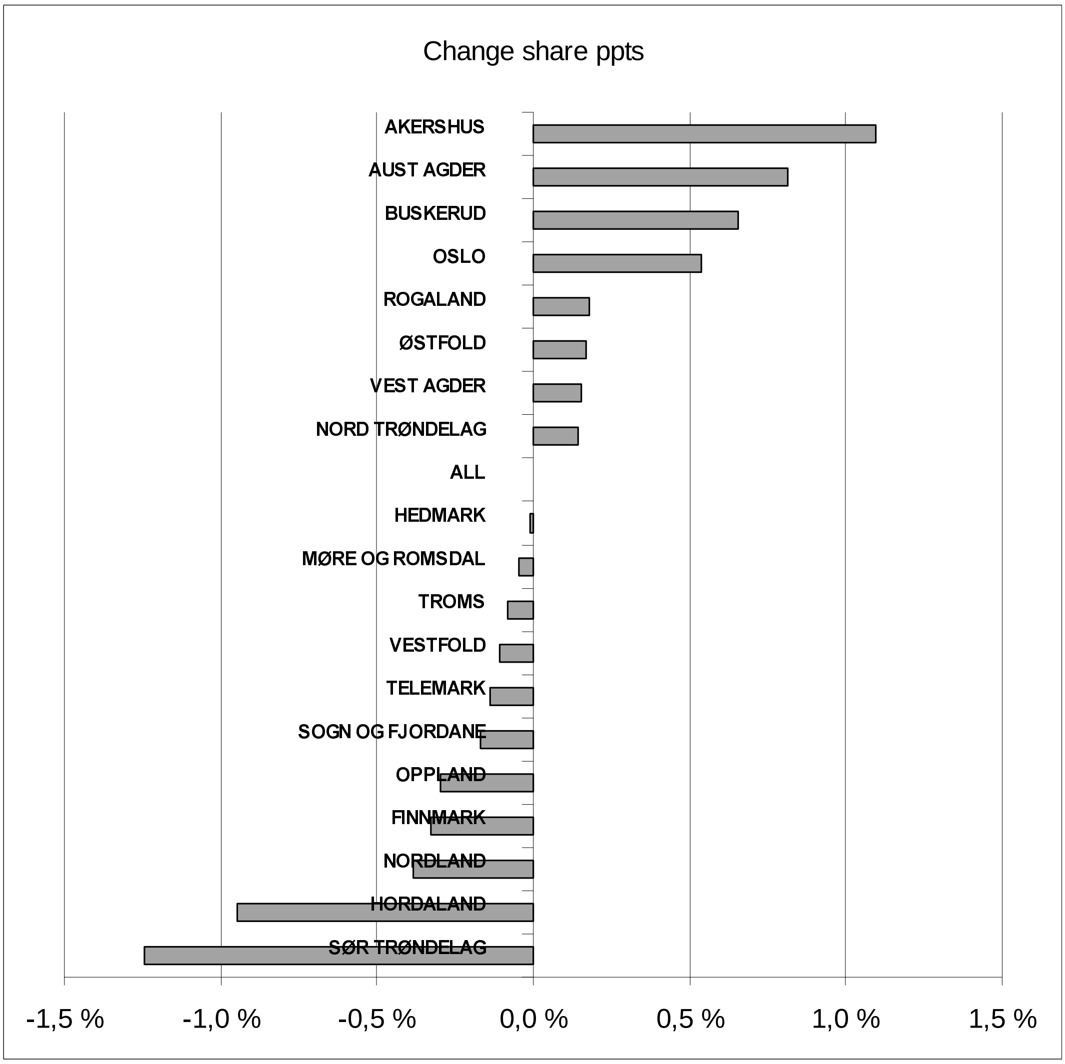


Figure 23: Change in share of ICT skilled working in county, 1989-1999

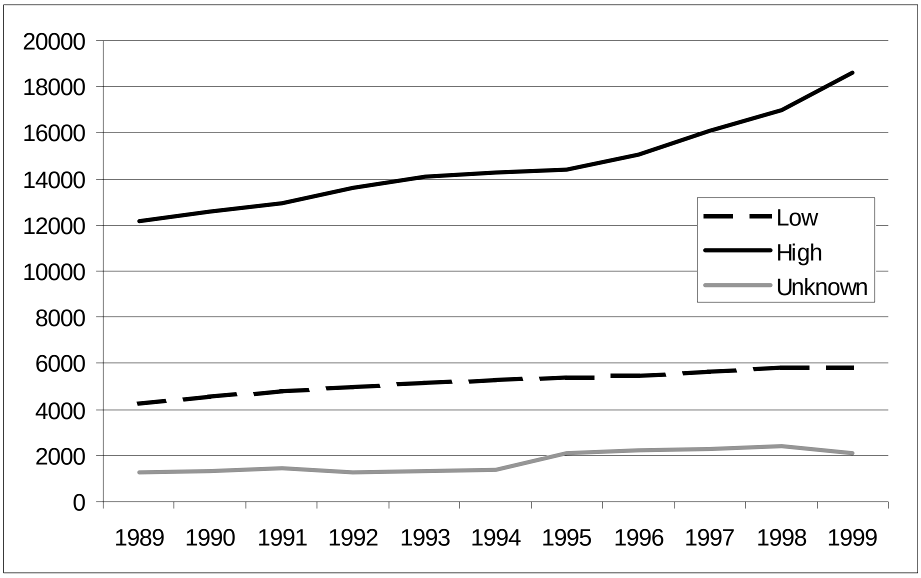


Although the county-wise results above tell us much about the regional distribution of ICT skills, they do not say anything about the distribution between different types of regions within counties. For example, we would expect that ICT skilled persons in increasing amounts tend to move to cities or urban areas. Such patterns are not, perhaps with the exception of Oslo, found in the presentation above.

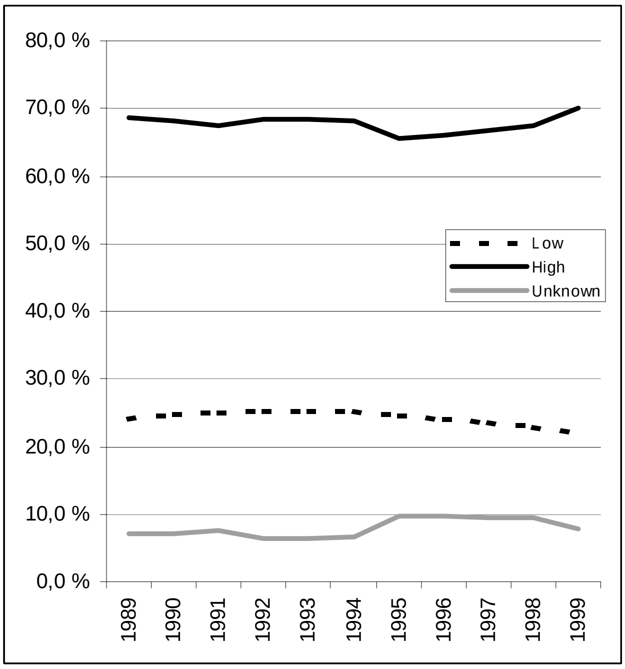
National Statistics categorises Norwegian communities with respect to centrality; i.e. the size and range of services provided in a community, where communities with a higher population density and a broad range of services are given high centrality, etc.

The following figure shows how work location for ICT-skilled persons has evolved during the 90s. The figure shows two things: Firstly, that the number of persons working in central areas is about three times higher than people working in less central areas. Secondly, there is a clear tendency towards an increased number of ICT-skilled in central areas over time. 80 percent of all newcomers have found jobs in areas ranked highest on the centrality index.

Figure 24: Number of ICT-skilled by geographical centrality, 1989-1999 (Low = 0,1 and 2, High = 3).



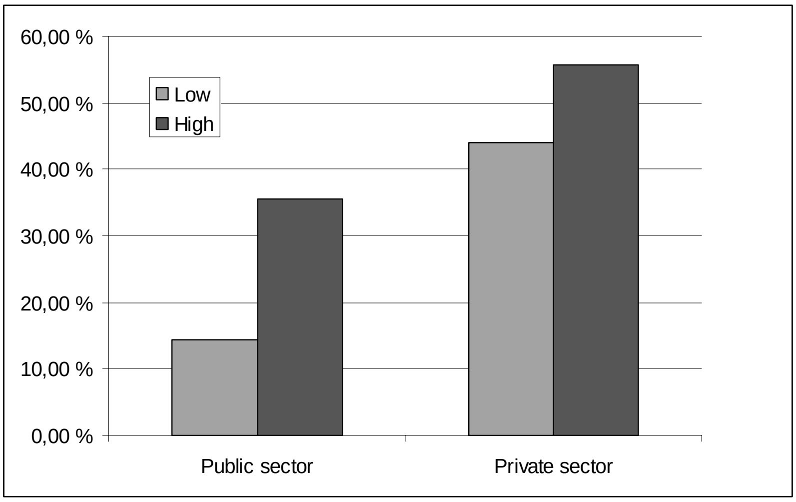
However, the relative distribution between the two types of regions has not changed profoundly. In other words, the successive distribution between 1989 and 1999 has followed an already established pattern: Measured as share of ICT-skilled persons working in respective regions, high centrality regions stay on about 70 percent throughout the whole period, while low centrality regions stay around 25 percent, with a slight decrease the last years.



We have seen that it is mainly private sector that has gained most of the new ICT-skilled persons during the 90s. At the same time, 80 percent of all new entrants find work in central regions. There is in other words a strong tendency to attract ICT-skills into private companies in central regions, to the disadvantage of other areas and sectors. But how does this pattern manifest more concretely? How large is the difference between public sector in central areas and private companies in rural areas? How much better off are private companies in central sector compared to public sector in rural areas?

The following figure shows the growth in ICT-skilled by region class and sector between 1989 and 1999. The figure shows that private sector has grown faster than public sector, regardless of centrality. It also shows that the growth in central private sector has been almost four times as rapid as public sector in rural areas. The growth difference between public and private sector in central areas is slightly less than in rural areas.

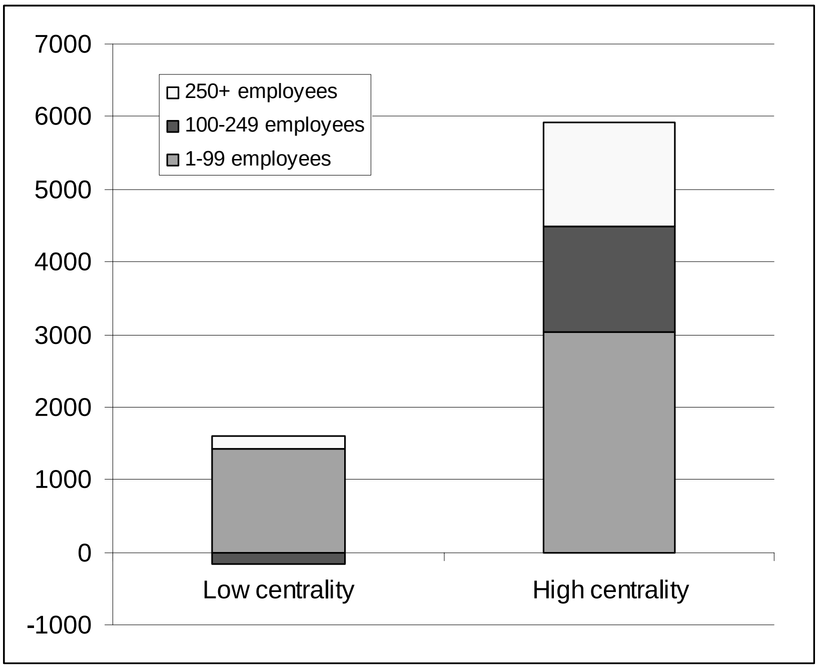
Figure 25: Growth in number of ICT-skilled by sector and centrality, 1989-1999



How has the distribution taken place with regards to centrality and company size classes? We have seen that most new employees go to private companies in central areas, but that more people in general go to small companies (due to overall growth in employment in small companies during the 90s).

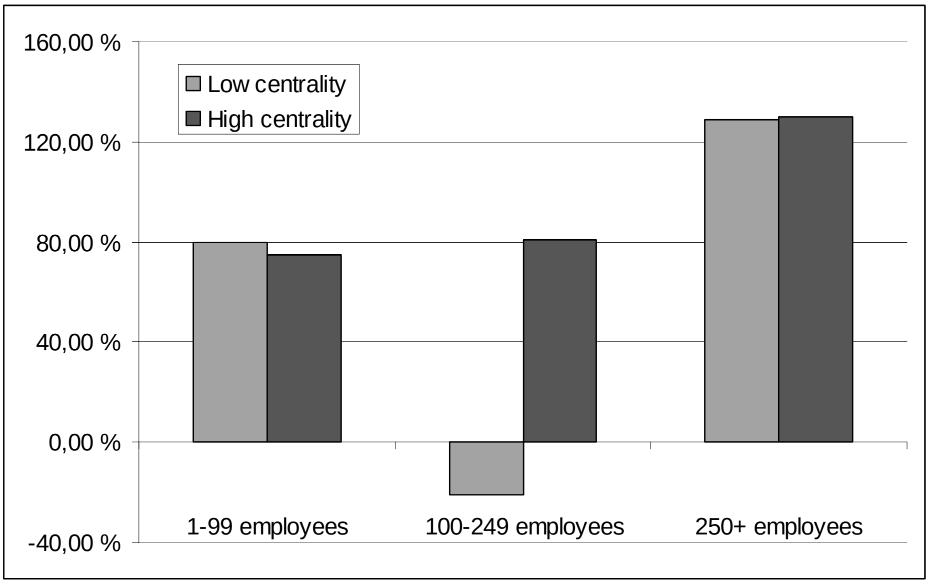
The next figures show how these patterns vary when we break the figures down on size class and centrality. In number of persons, about 3.000 new employees (of a total of about 7.500) have entered small companies in central areas. About 1.500 has entered in both medium- and larger sized companies. In rural areas, the distribution between small companies and the other companies is much more uneven. Of about 1.500 new persons between 1989 and 1999, 1.400 of them went to small companies.

Figure 26: Change in number of employees in private companies, by centrality and company size class, in number of ICT skilled persons



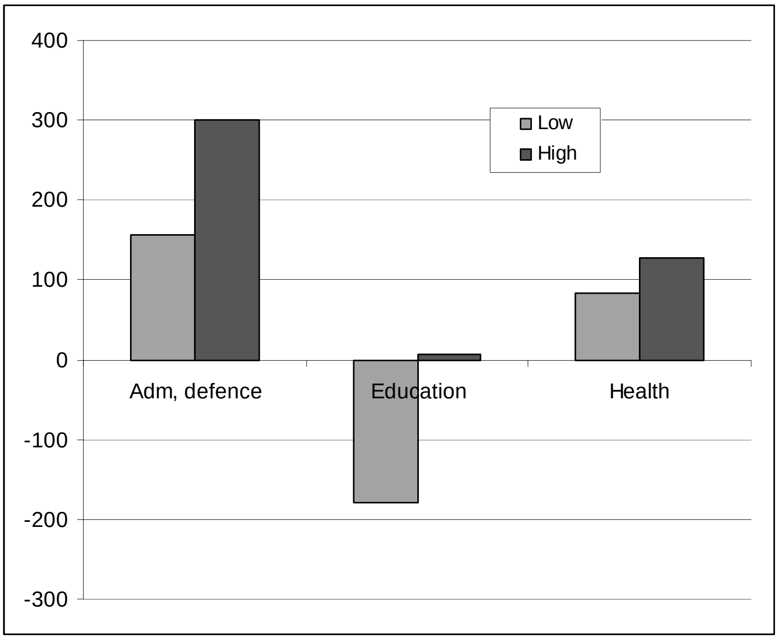
Looking at small companies in percent, the growth has been exactly the same in both region types. The same goes for larger companies. For medium-sized companies, the difference is more marked between the two region types. While companies in rural areas actually have experienced a net loss of ICT-skilled people, companies in central areas have grown with about 80 percent.

Figure 27: Change in number of employees in private companies,1989-1999, by centrality and company size class, percentages



Quite interesting patterns also appear when we look at public sector across different types of regions (Figure 28). We see that public sector in rural areas has experienced a much slower development in ICT-skilled persons than central areas. Within public administration and defence, the increase is twice as high. Within Education, rural areas have lost about 200 persons, while the number in central areas has been stable between 1989 and 1999.

Figure 28: Change in number of ICT-skilled persons in public sector, by centrality, 1989 to 1999



3.6 Summing up

More ICT-skilled persons work in small companies than before. However, the reason is that more people *in general* work in small companies than before. If we look at ICT density, large companies have in the 90s experienced a much higher density *growth* than small companies have.

Many user industries have increased their ICT density through replacing traditional staff with ICT skilled people. This is particularly typical in industries like Printing and publishing, Food and beverages, Chemicals, Transport equipment, Machinery and equipment and Metal goods (Figure 13).

Public sector has been the great loser in attracting ICT-skills during the 90s, and Education is particularly bad off.

ICT skills are dominantly localized to central areas, in particular the capital area. About 45 percent of all ICT-skilled persons work here, compared to about ¼ of all employees (1999). The share working in central areas is quite stable over time.

Private sector has grown faster than public sector, regardless of centrality. The growth in central private sector has been almost four times as rapid as public sector in rural areas. The growth difference between public and private sector in central areas is slightly less than in rural areas.

Although ICT is said to represent new possibilities for rural areas, we have seen that there are large and stable regional unevenness with respect to where ICT competent people work. Companies locate in central areas because this is where they find skilled employees. People work in these areas because this is where they find jobs, in addition to the often-mentioned aspects like cultural and social possibilities that larger density areas represent. This phenomenon represents a circle that is not easily broken, and it is also a question whether it is important, not to say technologically or economically beneficial or even possible, to break it[25].

Chapter 4. ICT competencies and careers

4.1 Background

When employees move, they bring with them work experience, networks and new ideas to a new workplace. This is the reason why mobility and careers is of interest in innovation studies, and in particular in a study of ICT competencies like this.

But at the same time as mobility is important, there is also a limit to what is a desirable level of mobility; suffice to mention labor marked and company instability, fragmentation of learning processes and dissolving of group feeling in workplaces. However, there have been several policy measures to stimulate personnel mobility on the basis that 'the more mobility, the merrier', more or less detached from any realistic mapping of actual mobility or any assumptions of what constitute 'normal' mobility activities.

In our view, a central starting point to ICT mobility and labor politics would be to establish simple facts around how individuals with ICT competencies actually change jobs. Do people move from small to large companies, or the other way around? Do they move from public to private sector, or do private sector in larger degree attract new persons entering the labor market? Do ICT-skilled move from rural to central areas, or do these regions first and foremost attract new people?

The following section aims to answer these questions. We use a panel study approach; starting with all ICT-skilled in 1989.

4.2 The panel

In this section, we follow a panel of ICT skilled people from 1989, to see what kind of career pattern they followed. In 1989, the panel consists of 17.698 persons, whereof 90 percent were men. About 45 percent were born in the 50s, as shown in Figure 29[26].

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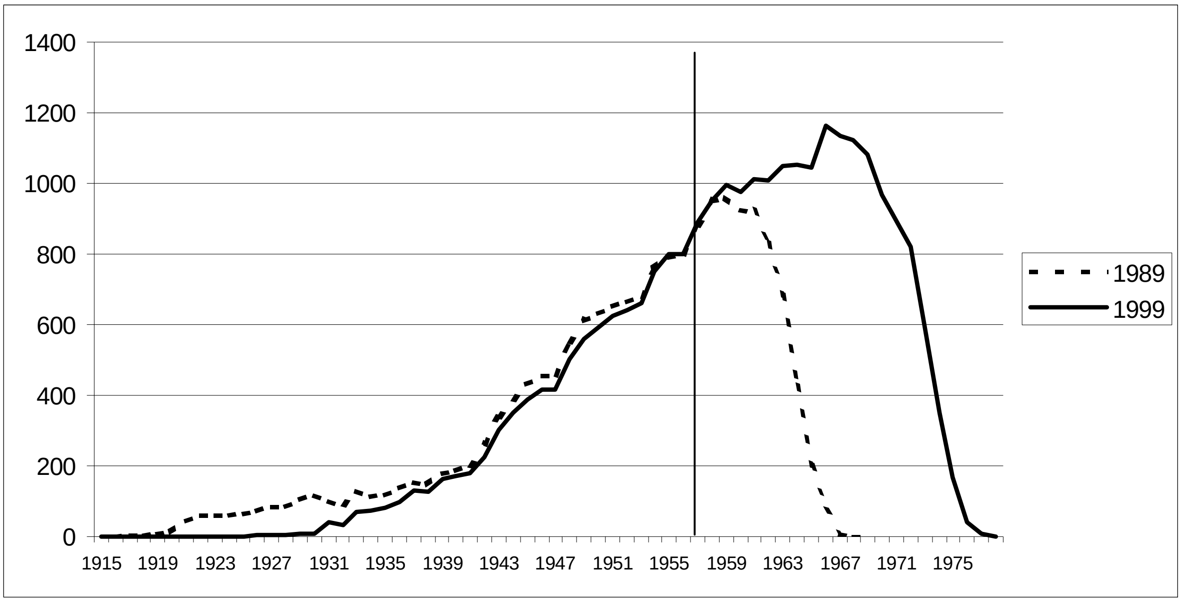
[25] In this respect, the establishment of IT Fornebu does not represent an immediate threat to the non-capital regions, as a large proportion of the ICT employees already work or live in the capital region.

[26] The figure also shows that the persons with higher ICT education born in the 50s have not increased at all between 1989 and 1999. One would perhaps expect that some formal up-skilling would have

Figure 29: Year of birth and number of ICT-skilled, 1989 and 1999



About 40 percent of the sample worked in small companies, while 70 percent worked in central areas. 15 percent worked in public sector, whereof more than half in Education. An overview of starting data is provided in the table below.

taken place in these vintages, but the whole increase in ICT-skilled persons entering the labour market in the 90s were born in the 60s, most of them in 1967 (1.200 persons).

Table 13: Panel data overview, 1989 and 1999[27]

All sectors	**Panel in 1989**	**Panel in 1999**	**1989 panel in 1999 as share of all in 1999**
Number of persons	17.698	14.257	54 %
Rural	24 %	24 %	59 %
Central	69 %	70 %	53 %
Unknown region	7 %	6 %	41 %
Women	10 %	9 %	52 %
Men	90 %	91 %	69 %
Private sector	79 %	80 %	55 %
Public sector	15 %	13 %	54 %
Unknown sector	6 %	7 %	41 %
Private sector			
Small	42 %	42 %	48 %
Medium	19 %	19 %	57 %
Large	40 %	39 %	64 %
Public sector			
Public adm., defence	38 %	39 %	45 %
Education	56 %	43 %	67 %
Health care	6 %	8 %	33 %

4.3 Results

4.3.1 General patterns

We have already raised the question where new entrants tend to locate, with respect to region, sector and size classes. The third column in the table provides some background data on where we find persons from our panel still in work in 1999. The column shows how large share our panel represented in 1999, as share of all ICT-skilled in 1999. The remaining share then represents the bulk of new entrants in the period 1990-1999.

For example, our 1989 panel in 1999 (14.257 persons) represented 55 percent of all ICT-skilled persons. 45 percent of the ICT-skilled working in 1999 was in other words new entrants from 1990 to 1999.

Reading the shares from column three in Table 13 as an inverse indication on where all the new employees have entered, provides us with a pretty good starting indication on where new persons go, and who they are:

[27] Figures for 1999 include ICT-skilled persons with full-time work (as defined above) in both 1989 and 1999.

- More women than men have entered in this period, compared to the share they had in 1989
- There has been no radical change between public and private sector in terms of where our panel is located ten years after. About 55 percent of 1999-employment come from our panel, in both sectors.
- More new employees go to small companies than large ones, while large companies tend to attract people with longer work experience: 64 percent of our panel in private sector were working in large companies in 1999.
- Few of the entrants go to Education. Persons from our 1989-panel represented as much as 2/3 of all ICT-skilled working in Education in 1999.

4.3.2 Stability and turnover of ICT-skilled persons, by industry

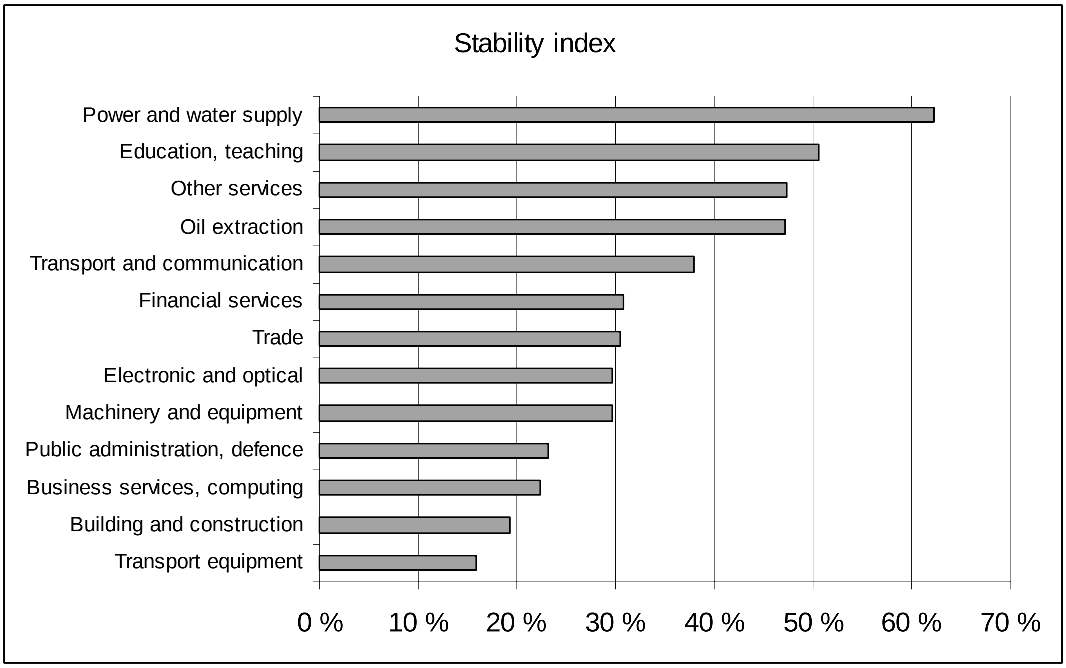
We have mentioned before that there is a trade-off between experience and stability on the one hand, and turnover of new employees on the other. The problem is of course to find a canonical figure for a 'correct' turnover, and it is also a question if this is actually needed. On the other hand, a nihilistic approach to this question results in ignoring the fact that some industries are marked by a too high turnover, while other have a too low turnover.

One way to approach the question of ICT mobility is to look for variations in stability across different industries, to get an empirically informed picture of how stability and turnover vary. This is done in the figure below. The method we have used to find the number of ICT-skilled persons working in the same industry in both 1989 and 1999, and dividing them by all ICT employees in 1999 by industry. To avoid small industries or industries where ICT play a lesser role, we have only included industries with more than 500 ICT-skilled in 1999.

The results show that during a ten years period, between 30 and 40 percent of the ICT-skilled persons stay in the same industry[28]. There are more 'traffic' in industries like Transport Equipment, Building and Construction, Business services and Public administration/defense, while Power and water supply, Education, Other services and Oil extraction are industries with quite high stability.

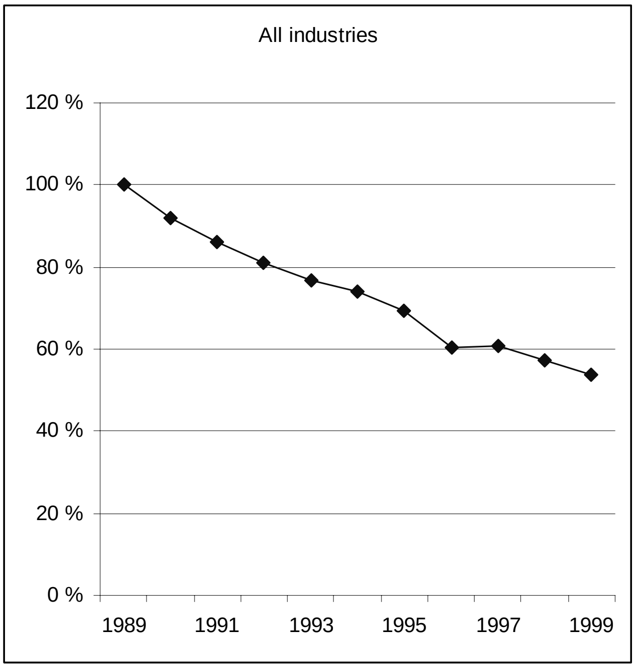
[28] We have not included the probability of people changing from one industry to another and back again between 1989 and 1999.

Figure 30: ICT stability in different industries: Share of all ICT-skilled employed persons in industry working in same industry both 1989 and 1999. Only industries with 500 or more ICT-skilled persons in 1999 included.



The following figure shows another, related way to map stability in industries over time. The figure takes as a starting point the panel in 1989, and follows these persons each year from 1990 to 1999, measuring them as share of all ICT-employment. What the figure shows is actually an *experience proxy*, as it shows the share of ICT-skilled persons in the labor marked that has been working at least since 1989.

Figure 31: ICT experience, measured as ICT-skilled employees in 1989 as share of all ICT-skilled working, 1990-1999



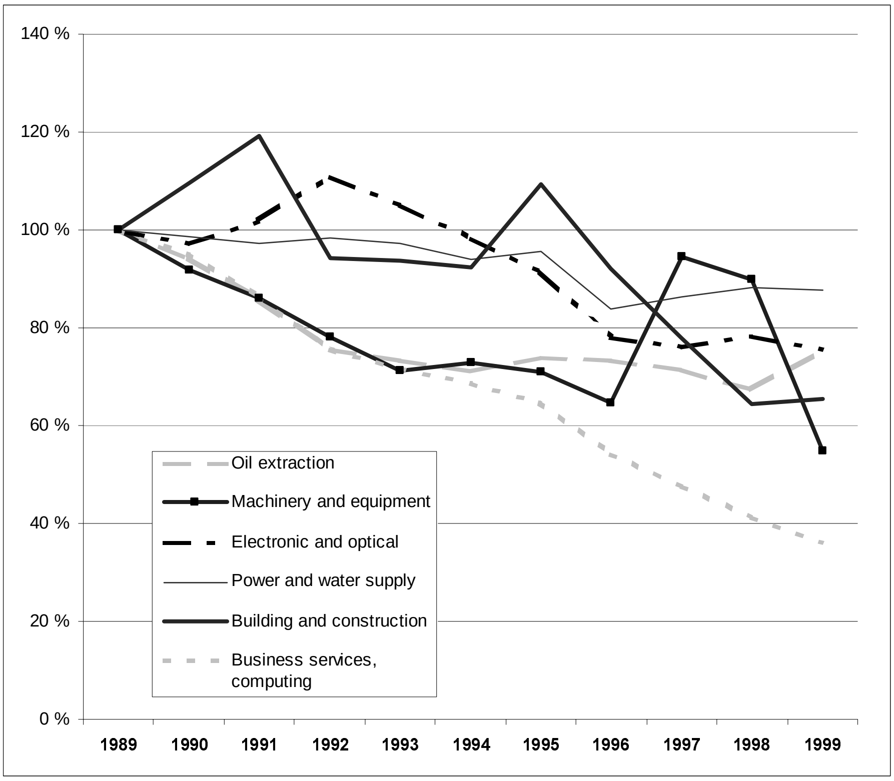
Although the line is broken by what we believe is 1996 statistical transition problems (ref. Footnote 10), the figure shows overall steadiness: There has not been any period with particularly steep changes or flattening out in the share of persons with ICT skills and work experience. This builds up under the argument that even though there are turbulent periods in the labor market in general and in certain industries in particular, ICT competencies are diffused and used in a patiently manner across many industries.

Looking at industries in more detail, we find even more interesting patterns[29]. Firstly, we see that the low stability in Business services has been more profound than in other industries starting from the mid 90s. Before 1994, the pattern was not radical different from the others, but after 1994, the steady rate of people finding jobs in other industries continued.

We also find that from 1993-1994, it seems that oil companies have kept many of their most experienced ICT-skilled staff. Until 1993, the stability was more or less equal to national patterns, but from this point an onward, the share of 1989 staff is almost constant.

[29] A perhaps surprising result is the fact that figures sometimes exceed 100 percent. The reason is most likely that we cling to the ICT panel from 1989 and follow them forward on, *regardless of changes in their education*. This means that when a sufficient number of 1989 ICT persons working in an industry gets another education or exam, the total number of ICT-skilled persons in this industry is reduced, while we keep our panel as it was from the start.

Figure 32: ICT stability in different selected industries, measured as ICT-skilled employees in 1989 as share of all ICT-skilled working in industry 1990-1999



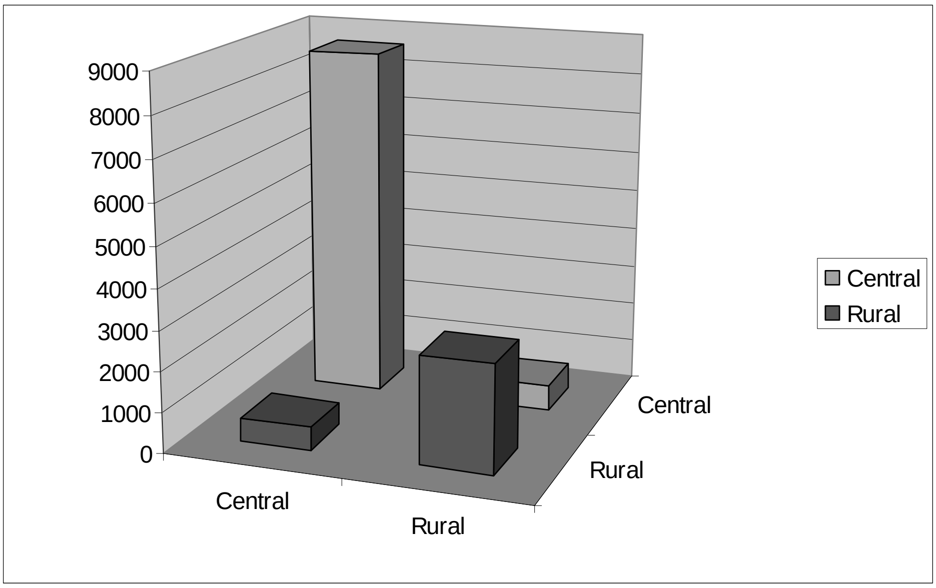
4.3.3 Mobility by centrality

A central question in regional policy is access to skilled persons in rural areas. Two questions have in particular been raised on this background: How is it possible to keep skilled people in rural areas, and how is it possible to make skilled people move to rural areas.

These questions go beyond the aim of our study, but a central aspect to such questions is a mapping of existing mobility patterns. Figure 33 provides an overview of mobility between central and rural areas between 1989 and 1999, using our panel data: We start with about 10.000 persons working in central areas, and 3.500 working in rural areas. Where have they gone, ten years after?

As the figure clearly shows, the dominant pattern is stability in both rural and central areas. About 90 percent have not changed centrality between 1989 and 1999. In addition, we actually find a net positive mobility from central to rural areas, and not the opposite. The reason is partly the fact that there are so many persons working in central areas in 1989. Measured in percent, the share moving from rural to rural to central areas is much higher (18 percent) than the other way around (seven percent).

Figure 33: Mobility between rural and central areas, panel data, 1989-1999, in number of persons with ICT-skills (N = 12.510)

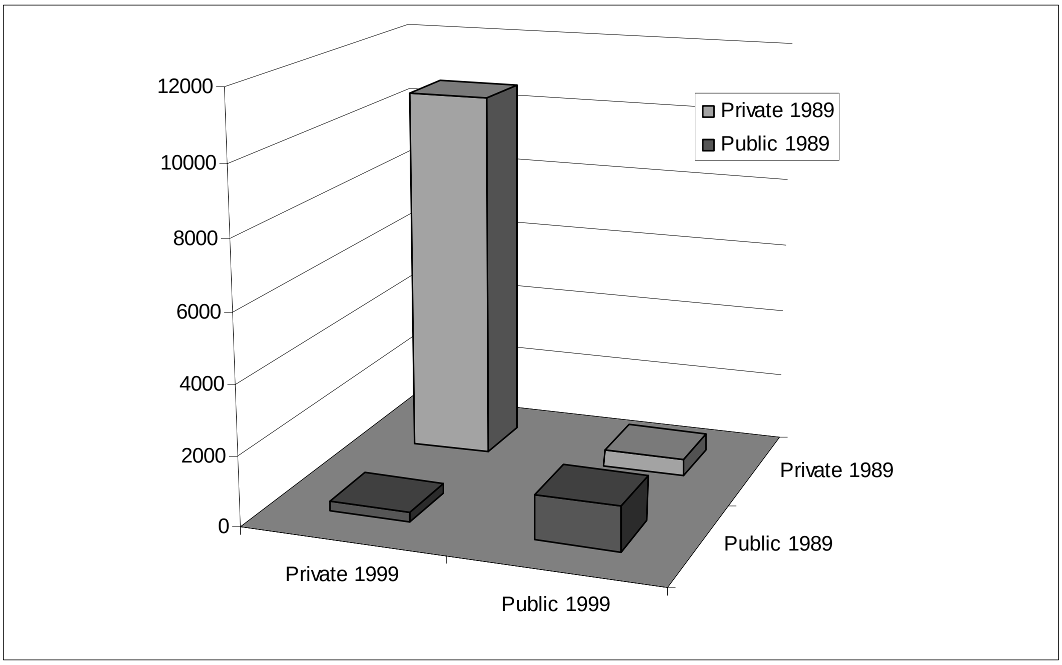


4.3.4 Mobility between sectors

We have established that public sector was the great loser in terms of access to ICT skills in the 90s. Is this a result of high turnover (many in, many out) or a result of few people going to public sector in the first place? The difference is quite important in terms of a better employment policy for public sector. Keeping hired people requires other solutions than if the problem is more to get people to enter public sector at all.

It seems that the problem is getting people to work in public sector, more than keeping them. The overview showed in the following figure shows that extremely few persons go from private to public sector, even for such a long time-span. From more than 10.000 persons working in private sector in 1989, only five percent worked in public sector in 1999 (figures include only persons). From public sector to private sector, the share was twice as high.

Figure 34: Mobility between private and public sector, panel data, 1989-1999, in number of persons with ICT-skills (N = 12.719)



4.4 Summing up

In this section, we have used panel data to investigate ICT mobility and stability patterns in the Norwegian economy. We have found that in some industries and activities, like Power and water supply and Education, persons with ICT skills tend to stay longer in the same industry than for example turmoil-industries like Business services, Manufacturing of transport equipment and Building and Construction.

Mobility between different region types and different sectors seems, on the other hand, more stable. Those working in public sector in 1989 were most likely working in public sector in 1999 as well; the same goes for private sector. We have also found that persons seem to be quite stable in terms of centrality; those working in central areas in 1989 were most likely to work in central areas ten years after as well; the same with those working in rural areas.

Chapter 5. Summing up and policy implications

5.1 Summing up

In this report, we have shown that it is common to look at mere ICT producer industry statistics when accounting for national or regional ICT performance. Our study goes beyond this perspective, and empirically demonstrates how ICT represent a set of technologies that is widely applicable in many industries.

We have shown that although the number of ICT-skilled persons working in small, private companies has increased fast during the 90s, this must be related to a general increase in number of employees in small companies in this period. The density of ICT-skilled persons has increased most in the largest companies during the 90s. Dominant industries, measured in ICT skill density, are Power and water supply, Oil extraction and Machinery and equipment. The single largest ICT 'industry' is still Business services and computing, with about 6.000 employees with formal skills in ICT. The most ICT-intensive industry is still producer industries like Electronic and optical industries and Business services and computing.

Industries experiencing the fastest increase in ICT intensity, measured as higher-than-average ICT growth and lower-than-average overall employment growth, are Printing and publishing, Chemicals, Transport equipment, Machinery and equipment and Non-metal goods. Education is an industry that comes out least well in such an overview. This activity has both decreased number of ICT skilled and increased number of 'regular' employees, resulting in a profound decrease in ICT density.
Although public sector has slightly increased the number of ICT-skilled employees the last decade, this increase has neither matched the overall increase in public sector employment nor the increase in number of ICT-skilled persons. The result has been a profound relative decrease in ICT skills in public sector, particularly sharp in Education.

There is also a regional dimension to this. The number of ICT-skilled working in central areas is about three times higher than people working in less central areas. This is a stable pattern over time, meaning that the relative distribution between the two types of regions has not changed profoundly between 1989 and 1999. If we control for sector, we find that private sector ICT-skills has grown faster than in public sector, regardless of centrality. Growth in central private sector has been almost four times as rapid as public sector in rural areas. The growth difference between public and private sector in central areas is slightly less than in rural areas.

Using panel data over a ten-year time-span, between 30 and 40 percent of the ICT-skilled persons stay in the same industry. There is higher turbulence in industries like Transport Equipment, Building and Construction, Business services and Public administration/defense, while Power and water supply, Education, Other services and Oil extraction are industries with quite high stability. In terms of mobility between central and rural areas, the dominant pattern is stability. About 90 percent have not changed centrality between 1989 and 1999. In addition, we actually find a net positive mobility from central to rural areas, and not the opposite. The reason is partly the fact that there are so many persons working in central areas already. Measured in percent, the share moving from rural to rural to central areas is much higher (18 percent) than the other way around (seven percent).

5.2 Policy implications

A central point to our study has been to move focus from manufacturing ICT industries alone also to include ICT activities taking place in user industries. We have shown that a substantial amount of ICT competencies in Norway are located in so-called user industries, however with varying intensities. The ICT competencies located in user industries represent about 60 percent of total national ICT competencies, with strong densities in Power and water supply, Oil extraction and Machinery and equipment. This brings forward a question whether it is actually natural to distinguish between producer industries on the one hand and user industries on the other, or if one should rather speak of industries with different ICT intensities, regardless of product category. A central point for policies in this area is to support developments of international standards for statistics that go beyond the existing product-oriented industry classification.

If one subscribes to the idea that user competencies are important, the immediate question is then: In what industries do we find substantial competence gaps? Where should policy-makers focus their attention, in order to improve the overall performance of the economic system?

The most burning issue is whether there are too many or too few persons with ICT competencies in the economy. Given the lack of such skills in Public sector in general and Education in particular, the immediate answer is ‘there are too few’. For example, bringing Education up to a national density level would require 2.000 more ICT-skilled persons[30]. Other Norwegian studies of supply and demand of ICT-skills support our view that there are too few ICT-skilled persons[31].

What separates this paper from such other studies is that it provides a very detailed overview of *where* ICT skills are located, and where they are not, which could serve as a basis for a detailed analysis of where we find immediate competence gaps. Unfortunately, the <u>positive</u> figures we have provided do not automatically provide any direct suggestion for <u>normative</u> policies. Although industries, regions and company size classes vary in both intensity and number of ICT-skilled persons, these patterns may just be interpreted as expressions of an optimal allocation under restraining conditions: Some industries have more need for ICT-skills than other industries, some company size classes have more need for ICT skills than others. Those that really find utiliy of such competencies will pay for it, and those that can’t pay for it don’t find the same utility in exploiting such knowledges: This is why we find differences. The policy implication would therefore be to do nothing.

However, no industry in Norway operates under perfect marked conditions. Company size, uneven distribution of capital, information and knowledge etc. are factors that go against a laissez-faire approach to such questions. We have for example shown that Education is one of the areas that have experienced reduced ICT content both in relative and absolute terms. First of all, a better policy to stimulate ICT recruitment to Education is highly necessary.

Looking closer at each industry and size class, we have seen that for some industries we find patterns of uneven distribution. Power and water supply and Printing and publishing are both industries that have ICT skill surplus in small companies, to the

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[30] However, such figures do not take into consideration the number of persons with informal ICT skills. A mapping of the extent and distribution across industries and activities of such skills is beyond our scope in this report.

[31] For other Norwegian studies on the supply and demand of ICT competencies, see Arnesen et al (1997), Ekeland et al (1998), Fløisbonn et al (1997), Adolfsen et al (1994), ECON (1999), Eikeland (1998), NIFU (1985), Statskonsult (1999a, 1999b, 1999c)

disadvantage of large ones. Small Trade and Business services companies also have excess ICT competencies, but not so much to the disadvantage for other size classes. In Other services, large companies have ICT skill surplus to the disadvantage of small companies in the same industry. Building and construction has a much higher density in medium-sized companies than expected. Such results may be used as gateways or basis for targeted ICT competencies policies. Still, the figures must be treated with careful understanding of how such indications are constructed, and always together with qualititive studies or approaches.

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Appendix

Table 14: NACE categories constituting the ICT sector.

72,100	*Hardware consultancy*	*Old definition*
72,200	*Software consultancy*	
72,300	*Computing*	
72,400	*Maintenance of databases*	
72,500	*Maintenance and repair of office machinery and computers*	
72,600	*Other computing*	
64,200	*Telecomm*	
32,100	*Man. of electrical components*	
32,200	*Man. of radio and TV transmitters*	
32,300	*Man. of radio and TV receivers*	
30,010	*Man. of office machinery*	
30,020	*Man. of computers*	
51,640	*Wholesale of machinery and office equipment*	
22,330	*Reproduction of data and programs on electronic media*	
31,300	Man. of isolated cords and cables	New industries (added 2000)
33,200	Man. of measuring and controlling equipment	
33,300	Man. of industrial process control machinery	
51,433	Wholesale of radio and televisions	
51,434	Wholesale of records, music and videotapes	
51,654	Wholesale of machines and equipment for trade, transport and other services	
52,485	Retailing of computers, office machinery and telecommunication equipment	
71,330	Rental of office machinery	

Table 15: University and college ICT-related exam codes

ISCED CODE	Exam (in Norwegian)
551204	Informatikk, emnestudier (bifag)
551400	Utdanning i databehandling og systemarbeid
551401	Ingeniørhøgskole, treårig linje for edb-teknikk
551402	Ingeniørhøgskole, toårig linje i edb-teknikk
551403	Databehandling og systemarbeid, toårig studium
551404	Ingeniørhøgskole, tilleggskurs i edb-teknikk
551405	Teknisk fagskole, påbyggingsår i edb-teknikk
551406	Databehandling og systemarbeid, kortere kurs
551407	Edb for humanister, emnestudium - feil kode - se 529002
551408	Datahøgskole, halvannetårig deltidsstudium
551409	Edb-høgskole, 1. Avdeling
551410	Edb-høgskole, 2. Avdeling
551411	Informatikk, ettårig studium
551412	Datahøgskole, toårig deltidsstudium (adb-kandidat)
551413	Teknisk databehandling, ettårig videreutdanning
551415	Edb-studiet, nks høgskole, deltid
551416	Informasjonsteknologi, toårig studium

551417 Datahøgskole, toårig heltidsstudium
551418 Administrativ databehandling (adb), ettårig studium
551419 Informasjonsteknologi, ettårig studium
551420 Administrativ databehandling, 10 vekttall
556001 Ingeniørhøgskole, elektrotekniske fag, treårig linje
556002 Ingeniørhøgskole, elektrotekniske fag, studentlinje
556003 Ingeniørhøgskole, påbyggingsår i elektro
556200 Ingeniørutdanning i elektronikk (svakstrøm)
556201 Ingeniørutdanning, treårig linje i elektronikk
556202 Ingeniørhøgskole, toårig linje i elektronikk (svakstrøm)
556204 Ingeniørhøgskole, videreutdanning i industriell elektronikk
556205 Ingeniørhøgskole, videreutdanning i medisinsk teknikk
556207 Teknisk fagskole, påbygningsår i svakstrømsfag
556208 Maritim høgskole, elektro-/automasjonslinje
556209 Ingeniørhøgskole, tilleggsutdanning i dataassistert test og konstruksjon
556400 Ingeniørutdanning i automatiserings-(regulerings-)teknikk
556401 Ingeniørhøgskole, treårig linje i automatiseringsteknikk
556402 Ingeniørhøgskole, toårig linje i automatiseringsteknikk
556403 Teknisk fagskole, påbyggingsår i automasjonsteknikk
556405 Ingeniørutdanning, treårig linje i reguleringsteknikk
556406 Ingeniørhøgskole, toårig linje i reguleringsteknikk
556600 Programteknikerutdanning
556601 Programteknikerutdanning, lydteknikerkurs
556603 Programingeniørutdanning
556900 Elektrotekniske fag, annen utdanning
556904 Teleskolen, kurs i teleteknikk for ingeniører
559904 Ingeniørhøgskole, toårig grafisk linje med edb
561000 Maritime navigasjonsfag
632907 Edb og informatikk eller matematikk, halvårig videreutdanning/allmennlærere
651700 Edb-utdanning
651701 Edb-høgskole, 3. Avdeling
651702 Databehandling, toårig høgere studium
651703 Informasjonsteknologi, ettårig påbygning
651704 Datahøgskole, diplomoppgave
651705 Informasjonsteknologi, treårig studium
651901 Edb ved distriktshøgskole, ettårig tilleggskurs
651902 Datafag, treårig studium
655201 Ingeniørutdanning, treårig linje i flyteknikk
655203 Ingeniørutdanning, treårig linje i automatisering og datastyring
655241 Ingeniørutdanning, treårig linje i dataintegrert produksjon
655242 Ingeniørutdanning, treårig linje i prosessautomasjon
655249 Mekatronikk, videreutdanning for ingeniører e.l., 10 vekttall
656200 Ingeniørutdanning, elektrotekniske og datatekniske fag
656201 Ingeniørutdanning, treårig linje i elektronikk
656203 Ingeniørutdanning, treårig linje i automatiseringsteknikk
656205 Ingeniørutdanning, treårig linje i elektronikk/telematikk
656206 Ingeniørutdanning, treårig linje i elektronikk, mikroprosessorer og datatek
656207 Ingeniørutdanning, treårig linje i industriell elektronikk
656208 Ingeniørutdanning, treårig linje i teknisk kybernetikk
656209 Ingeniørutdanning, treårig linje i teleteknikk

656210 Ingeniørutdanning, treårig linje i mikroprosessorteknikk
656211 Ingeniørutdanning, treårig linje i medisinsk teknikk
656212 Ingeniørutdanning, treårig linje i data/elektronikk
656213 Ingeniørutdanning, treårig linje i tele/elektronikk
656214 Ingeniørutdanning, treårig linje i industriell automasjon og edb
656216 Ingeniørutdanning, treårig linje i mikroelektronikk
656217 Ingeniørutdanning, treårig linje i mikroelektronikk, dataass.konstruksjon
656218 Ingeniørutdanning, treårig linje i elektro/hydrauliske delsystemer
656219 Ingeniørutdanning, treårig utdanning i datateknikk
656220 Ingeniørutdanning, treårig utdanning i generell databehandling
656221 Ingeniørutdanning, treårig utdanning i teknisk databehandling
656222 Ingeniørutdanning, treårig utdanning i edb/databehandling
656223 Ingeniørutdanning, treårig utdanning i edb/adb
656224 Ingeniørutdanning, treårig utdanning i elektronisk databehandling
656225 Medisinsk teknikk, ettårig videreutdanning for ingeniører
656226 Konstruksjon av mikroelektronikk, ettårig videreutdanning for ingeniører
656227 Prosess-styring og reg v/hj.av datasyst.,ettårig vdrutd for ingeniører
656228 Edb, ettårig videreutdanning for ingeniører
656229 Maritim høgskole, l. For maritime ing., elektro/aut./maskin
656230 Ingeniørutdanning, treårig linje i avionikk
656231 Ingeniørutdanning, treårig linje i medieteknikk
656232 Ingeniørutdanning, treårig linje i prosess-styring
656233 Datateknikk, ettårig videreutdanning for ingeniører
656234 Ingeniørutdanning, treårig utdanning i robotteknologi
656235 Ingeniørutdanning, treårig linje i automasjon og prosesstyring
656236 Ingeniørutdanning, treårig linje i informatikk
656238 Ingeniørutdanning, treårig linje i informasjonsteknologi
656240 Prosessautomatisering, ettårig videreutdanning for ingeniører
656241 Ingeniørutdanning, treårig linje i teleteknikk/radioteknikk
656242 Telematikk, ettårig videreutdanning for ingeniører
656243 Ingeniørutdanning, treårig elektroingeniør industriell prosess-styring
656244 Ingeniørutdanning, treårig instrumentering og miljøovervaking(miljøteknol)
656245 Digital bildebehandling, ettårig videreutdanning for ingeniører
656297 Ingeniørutdanning, treårig linje i datafag generelt
656298 Ingeniørutdanning, treårig linje i elektrofag generelt
656299 Ingeniørutdanning, andre elektrotekniske og datatekniske fag
658226 Ingeniørutdanning, treårig, miljø- og geografiske informasjonssystemer
658227 Geografiske informasjonssystemer(gis), ettårig videreutd. For ingeniører
659002 Ingeniørutdanning, grafisk linje med utvidet edb
722601 Bibliotekhøgskole, videreutdanning i edb og informasjonskunnskap
751206 Cand.real, informatikk hovedfag
751207 Cand.real., databehandling hovedfag
751306 Informatikk, hovedfag
751307 Databehandling, hovedfag
751507 Mag.scient. I databehandling
751806 Cand.scient., informatikk hovedfag
751807 Cand.scient., databehandling hovedfag
752103 Kybernetikk, hovedfag
752203 Cand.real., kybernetikk hovedfag
752303 Cand.scient., kybernetikk, hovedfag

756000 Elektrotekniske og datatekniske fag
756100 Sivilingeniørutdanning, elektrotekniske fag
756101 Sivilingeniørstudiet, elektroteknikk
756103 Sivilingeniørstudiet, datateknikk og teknisk kybernetikk
756104 Sivilingeniørutdanning, industriell elektronikk
756900 Elektrotekniske og datatekniske fag, annen utdanning
759107 Sivilingeniørstudiet, linje for edb
759110 Sivilingeniørutdanning, informasjonsteknologi, spesialisering i datateknikk
759111 Sivilingeniørutdanning, informasjonsteknologi, spesialisering i kybernetikk
759113 Sivilingeniørutdanning, karttekniske fag
759116 Sivilingeniørutdanning, prosessautomasjon
851806 Dr.scient., informatikk

Table 16: Converter table for Aggregated NACE and NACE 2-digit industry

Aggregated NACE industry	NACE	Industry
Farming, forestry	1	Farming
	2	Forestry
	5	Fishing
Mining	10	Mining of coal
	12	Mining of uranium and thorium
	13	Mining of metals
	14	Other mining
Oil extraction	11	Oil and gas production
Food and beverages	15	Food and beverages
	16	Tobacco
Textiles, footwear	17	Textiles
	18	Clothing
	19	Leather
Wood and wood products	20	Wood and wood products
Pulp and paper	21	Pulp and paper
Printing and publishing	22	Printing and publishing
Chemicals	23	Coal and petroleum products
	24	Chemicals and chemical products
Rubber and plastics	25	Rubber and plastics
Non-metallic mineral products	26	Non-metallic mineral products
Metals	27	Metals
Metals goods	28	Metals goods
Machinery and equipment	29	Machinery and equipment
Electronic and optical	30	Office machinery
	31	Other electrical appliances
	32	Radio and television
	33	Medical instruments
Transport equipment	34	Vehicles
	35	Transport equipment (e.g. ships)
Furniture, other industries	36	Furniture, other manufacturing
	37	Recycling
Power and water supply	40	Electricity, gas, steam and hot water supply
	41	Water supply
Building and construction	45	Building and construction
Trade	50	Vehicle trade, gas stations
	51	Wholesale
	52	Retail
	55	Hotel and restaurants
Transport and communication	60	Land and pipe transport
	61	Sea transport
	62	Air transport
	63	Transport services, travel agencies
	64	Post and telecom
Financial services	65	Financial services
	66	Insurance companies
	67	Activities auxiliary to financial intermediation
Business services, computing	70	Real estate activities
	71	Machinery rental
	72	Computing
	73	Research and development
	74	Other business services
Public administration, defence	75	Public administration, defence
Education, teaching	80	Education, teaching
Health care and social services	85	Health and social services
Other services	90	Sewage and refuse disposal
	91	Membership organisations
	92	Recreation, cultural and sporting activities
	93	Other personal services
	95	Private housholds with employed persons
	99	Extra-territorial organisations

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STEP-gruppen ble etablert i 1991 for å forsyne beslutningstakere med forskning knyttet til alle sider ved innovasjon og teknologisk endring, med særlig vekt på forholdet mellom innovasjon, økonomisk vekst og de samfunnsmessige omgivelser. Basis for gruppens arbeid er erkjennelsen av at utviklingen innen vitenskap og teknologi er fundamental for økonomisk vekst. Det gjenstår likevel mange uløste problemer omkring hvordan prosessen med vitenskapelig og teknologisk endring forløper, og hvordan denne prosessen får samfunnsmessige og økonomiske konsekvenser. Forståelse av denne prosessen er av stor betydning for utformingen og iverksettelsen av forsknings-, teknologi- og innovasjonspolitikken. Forskningen i STEP-gruppen er derfor sentrert omkring historiske, økonomiske, sosiologiske og organisatoriske spørsmål som er relevante for de brede feltene innovasjonspolitikk og økonomisk vekst.

The STEP-group was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The basis of the group’s work is the recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unresolved problems about how the processes of scientific and technological change actually occur, and about how they have social and economic impacts. Resolving such problems is central to the formation and implementation of science, technology and innovation policy. The research of the STEP group centres on historical, economic, social and organisational issues relevant for broad fields of innovation policy and economic growth.